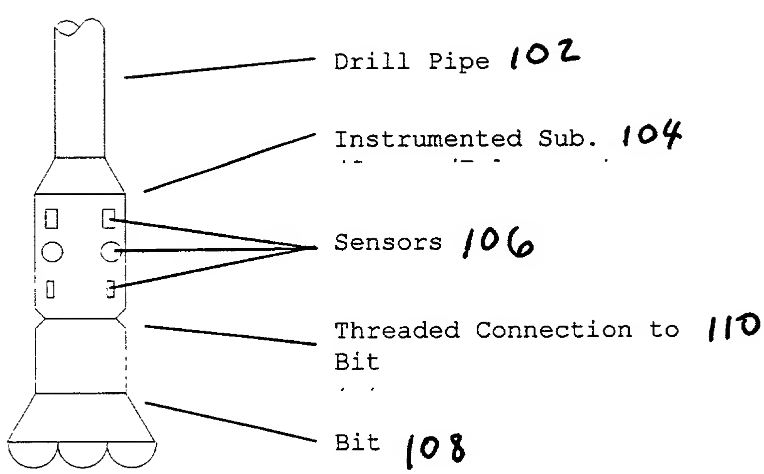


Figure 1. Sensor Placement Relative To Bit

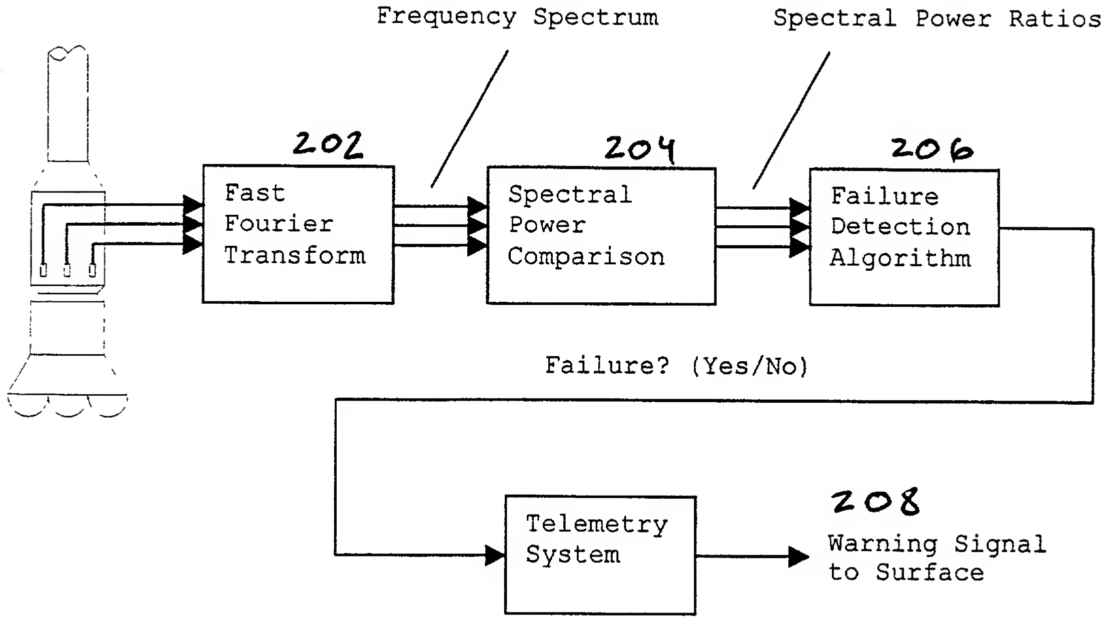


Figure 2

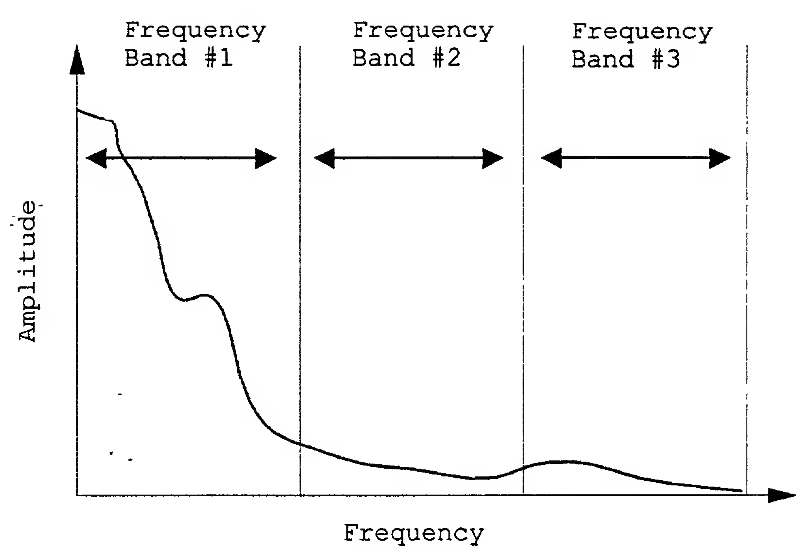


Figure 3. Frequency Band Arrangement

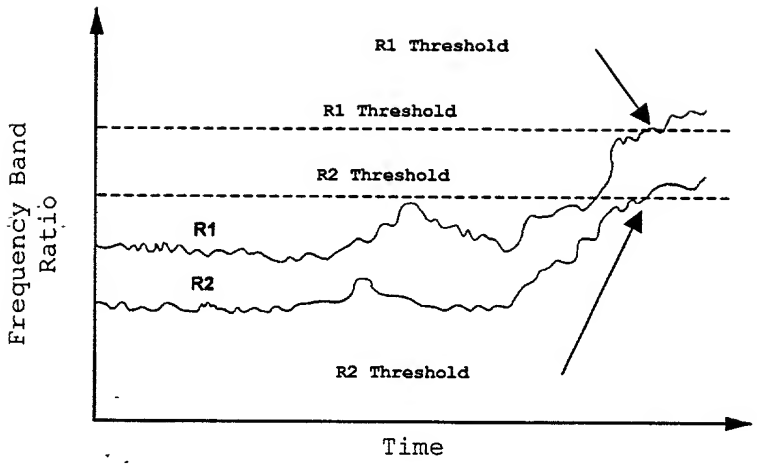


Figure 4. Threshold Failure Detection

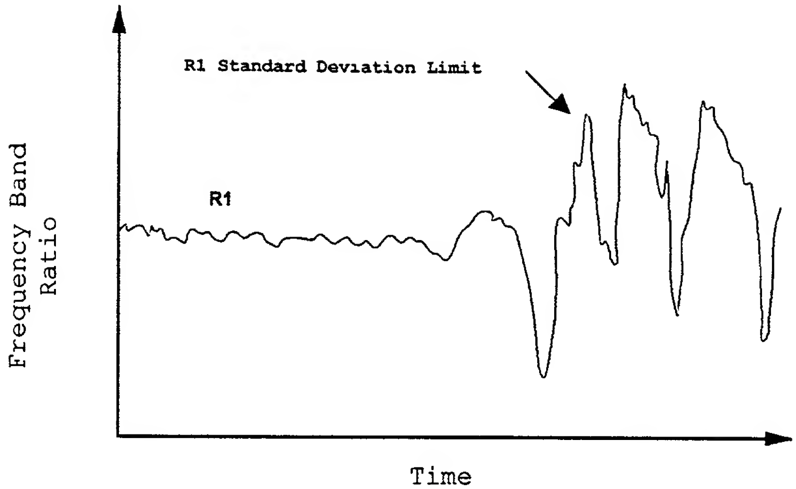


Figure 5 Statistical Failure Detection

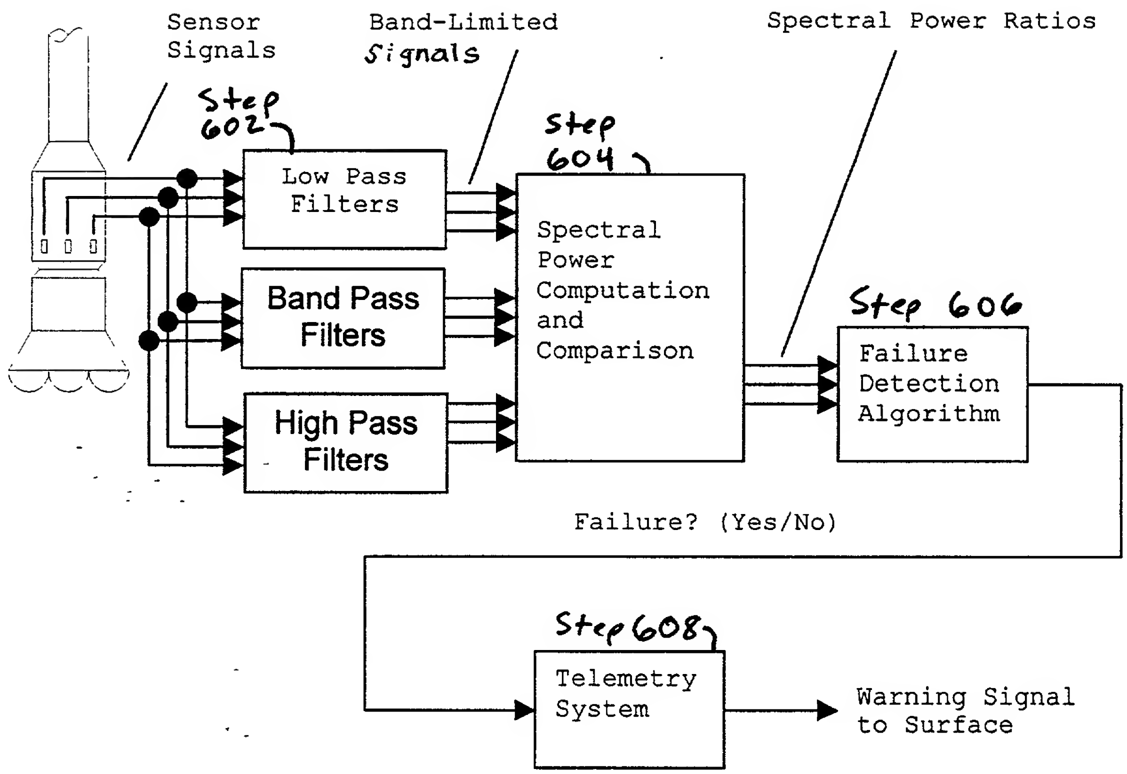


Figure 6 SPRA Method Using Analog Filters Spectral Power Separation

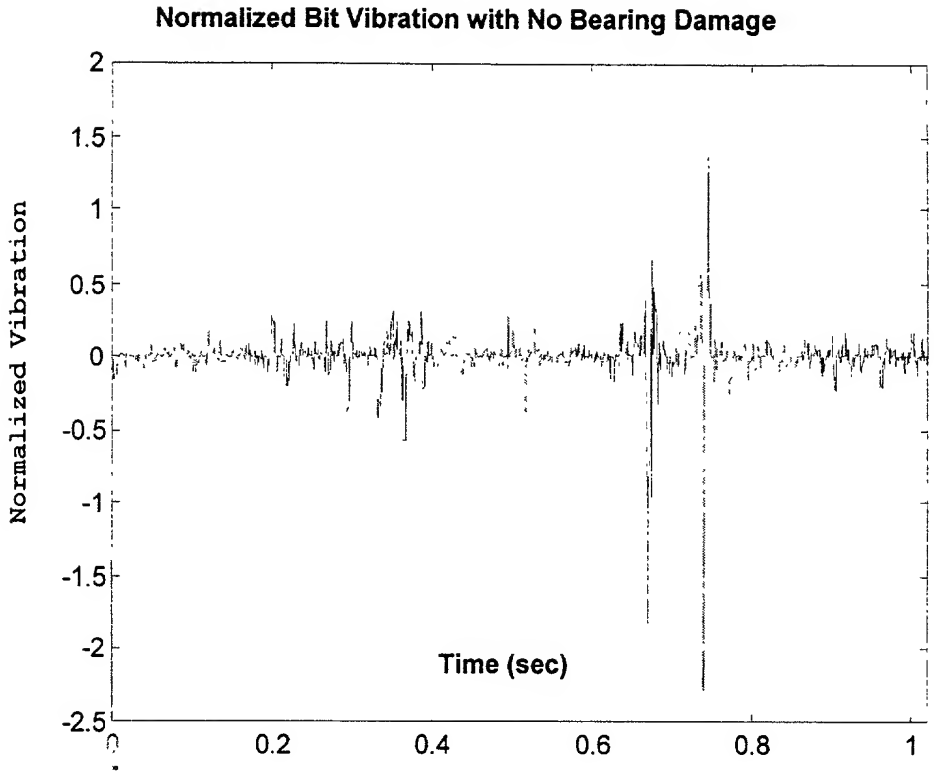

Normalized Bit Vibration with No Bearing Damage
Normalized Vibration
Time (sec)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0
0.2
0.4
0.6
0.8
1

Figure 7.

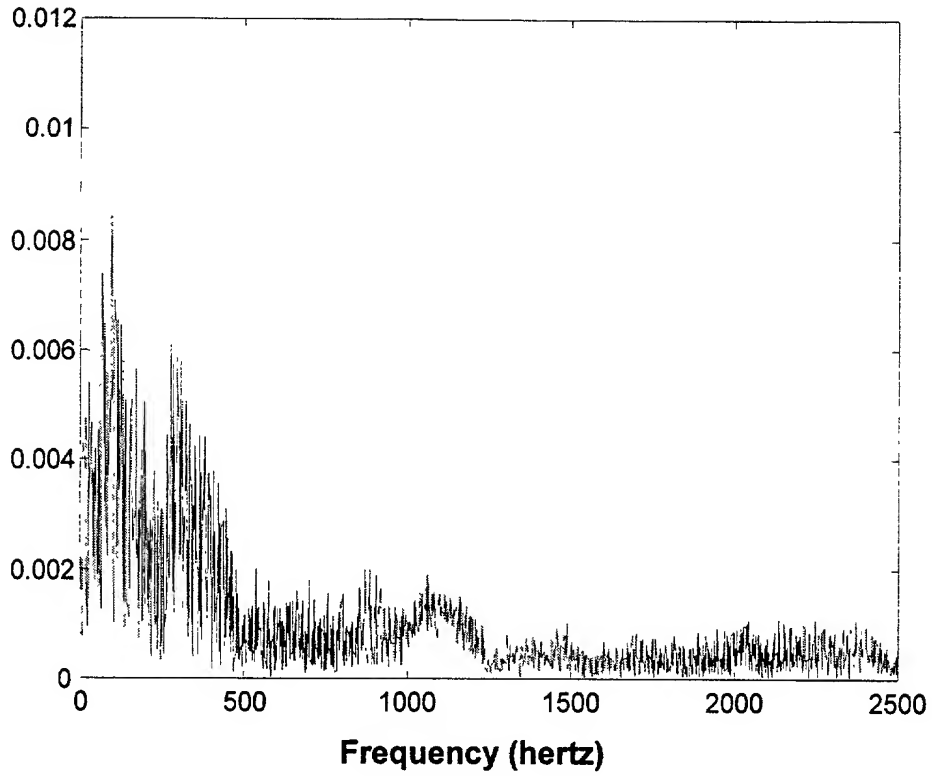

Discrete FFT of Vibration Data with No Bearing Damage
0.012
0.01
0.008
0.006
0.004
0.002
0
0
500
1000
1500
2000
2500
Frequency (hertz)

Figure 8.

Spectral Power Analysis Bearing with No Damage

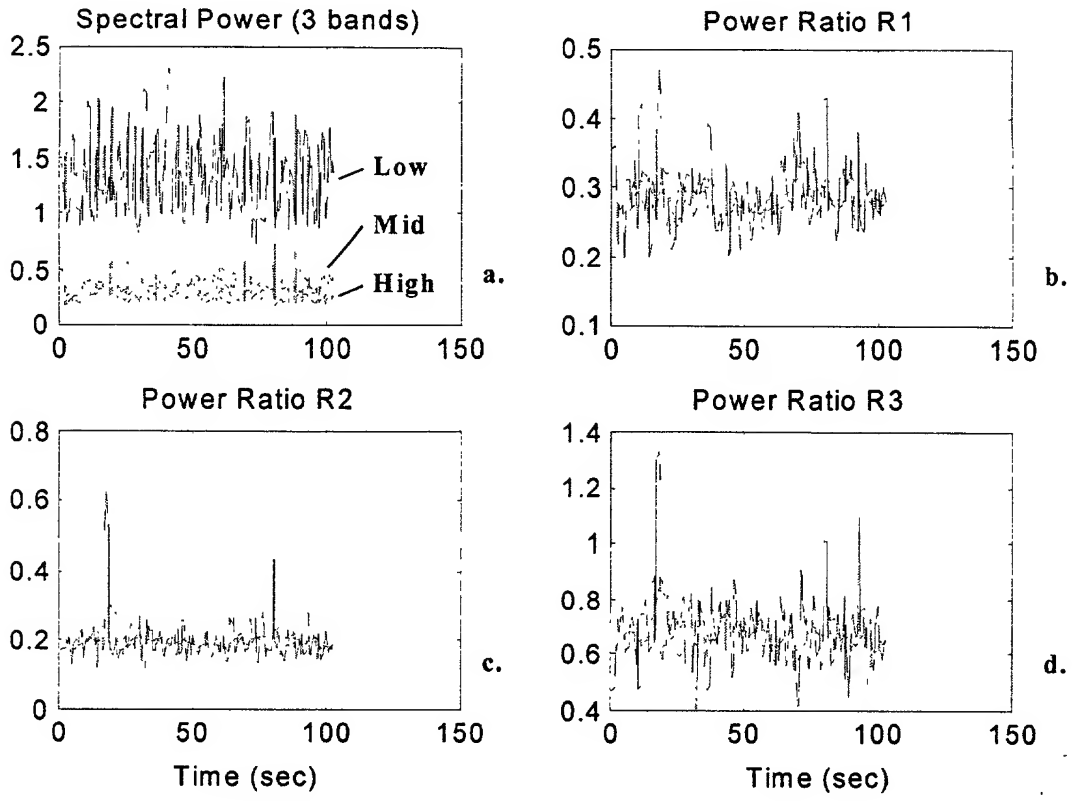


Figure 9.

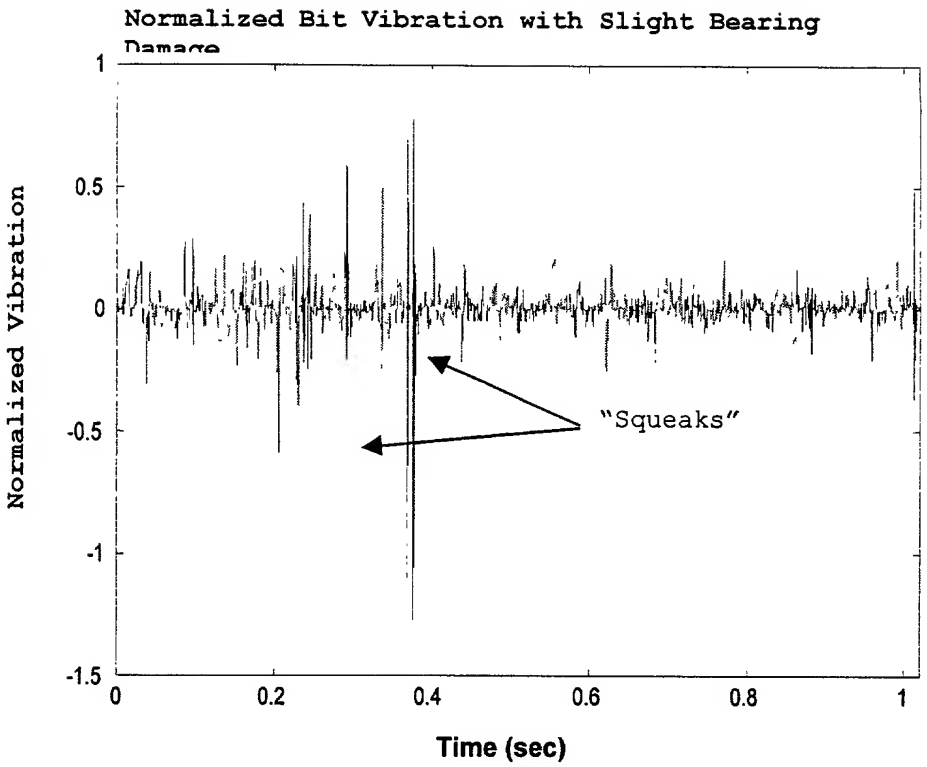

Normalized Bit Vibration with Slight Bearing
Damage
Normalized Vibration
1
0.5
0
-0.5
-1
-1.5
0
0.2
0.4
0.6
0.8
1
Time (sec)
"Squeaks"

Figure 10.

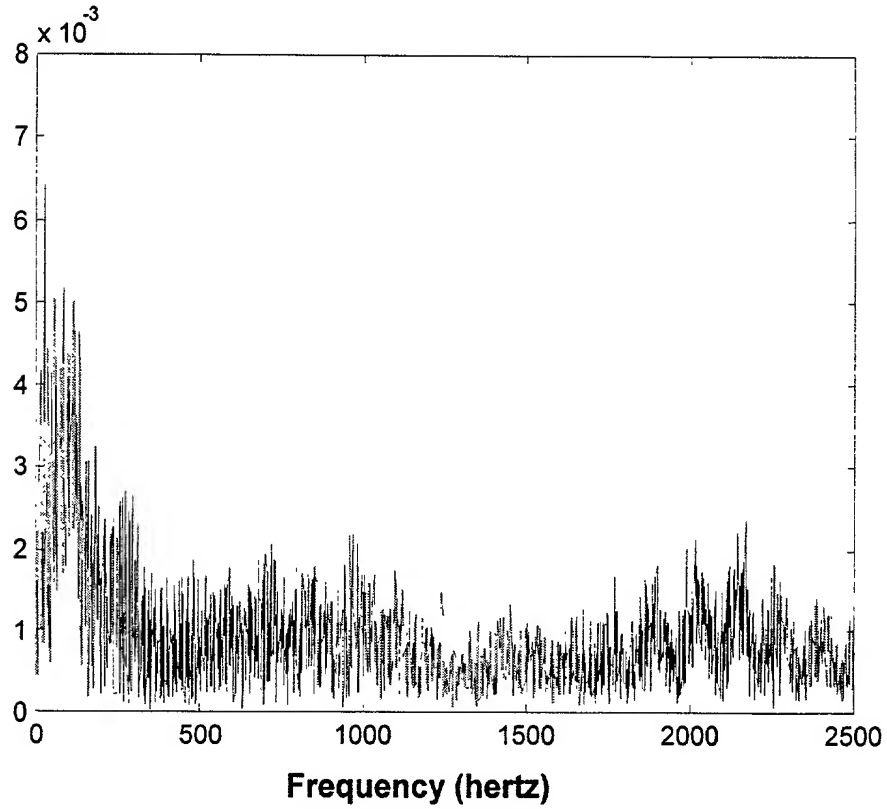


Figure 11.

Spectral Power Analysis for Slightly Damaged Bearing

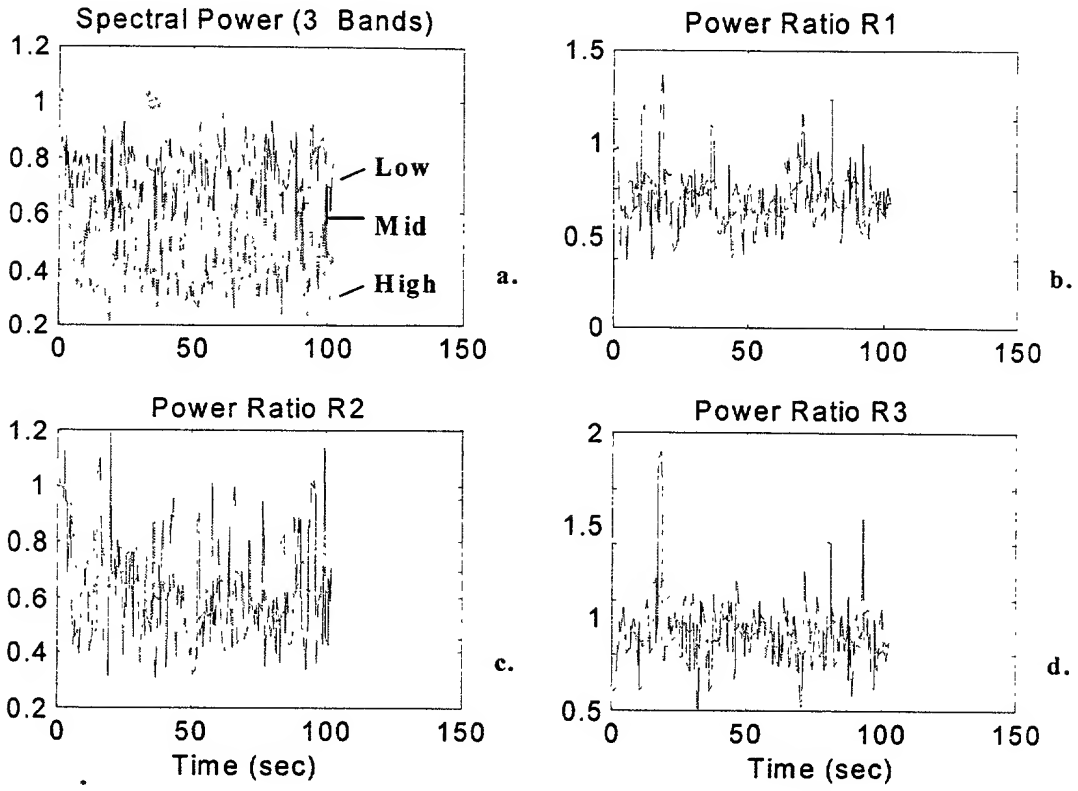


Figure 12.

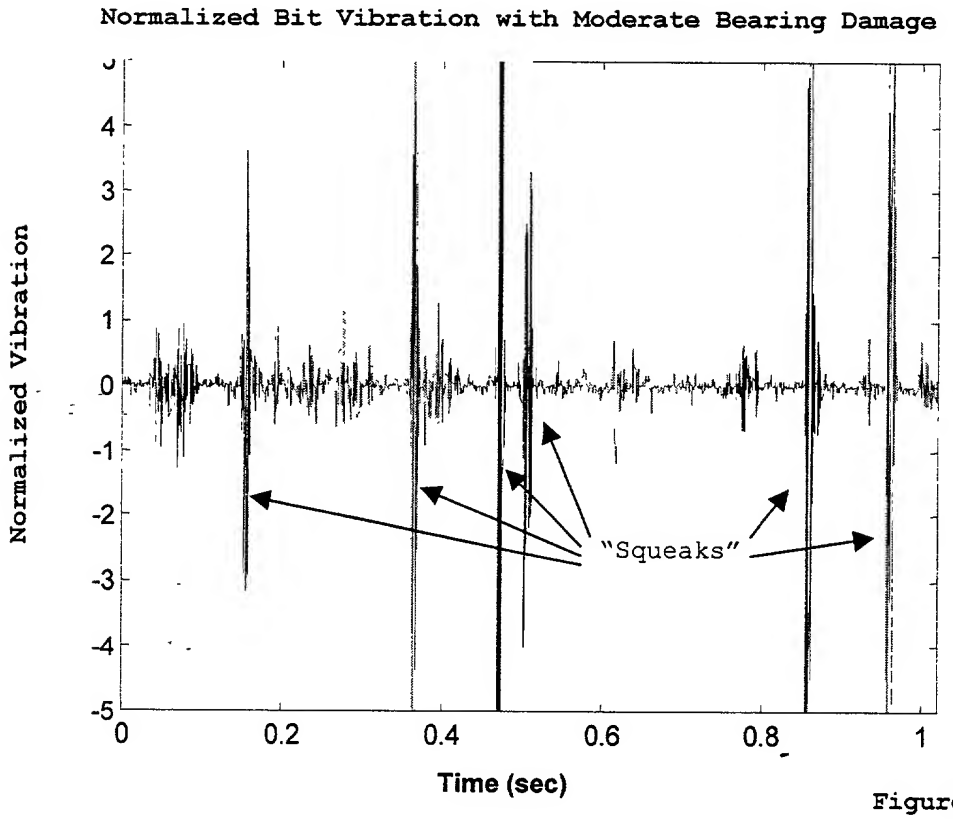


Figure 13.

Discrete FFT of Vibration Data for Moderate Bearing Damage

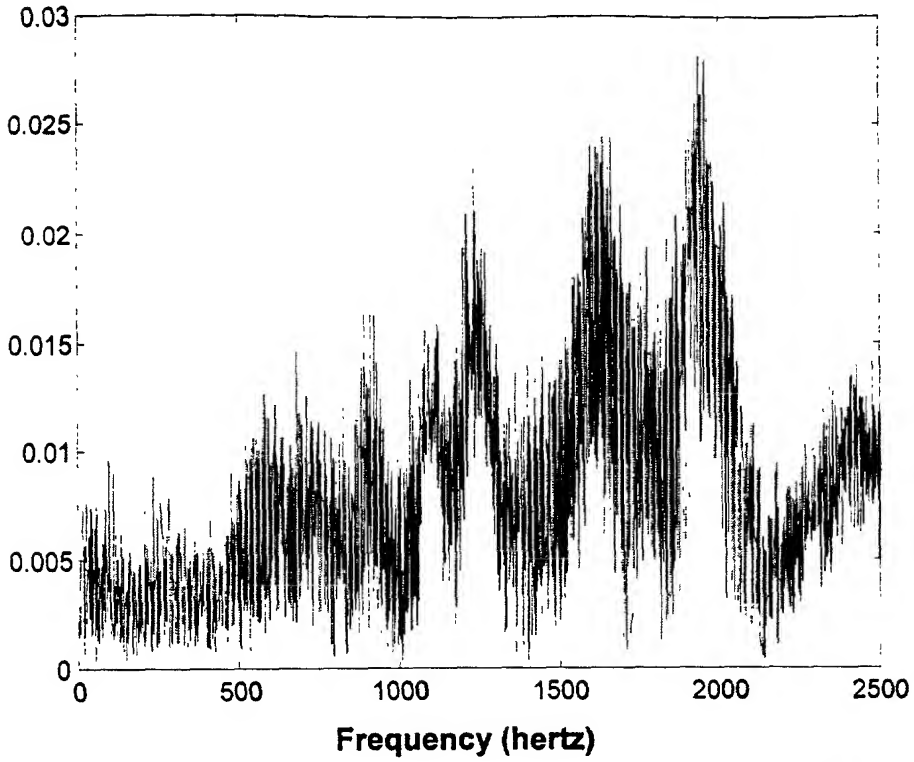


Figure 14.

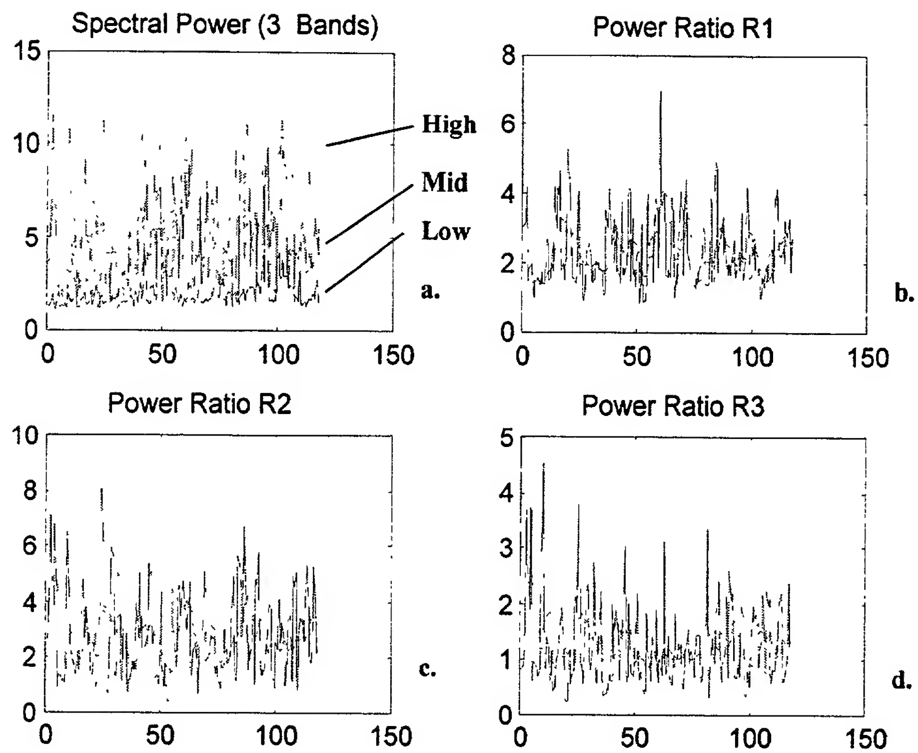


Figure 15.

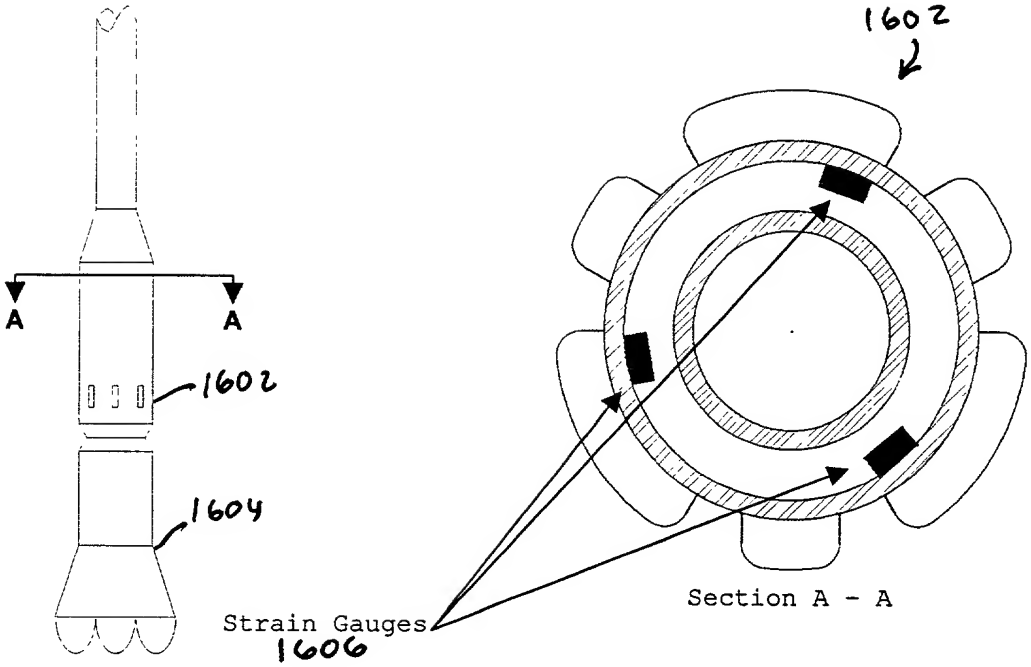


Figure 16. Strain Gauge Placement In Sensor Housing

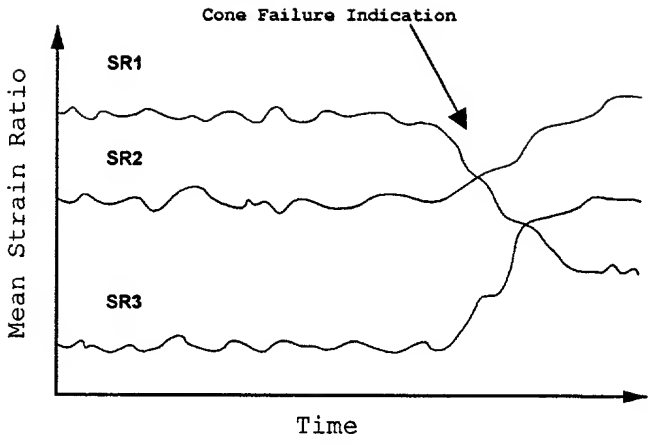


Figure 17. Failure Indication (MSRA Method)

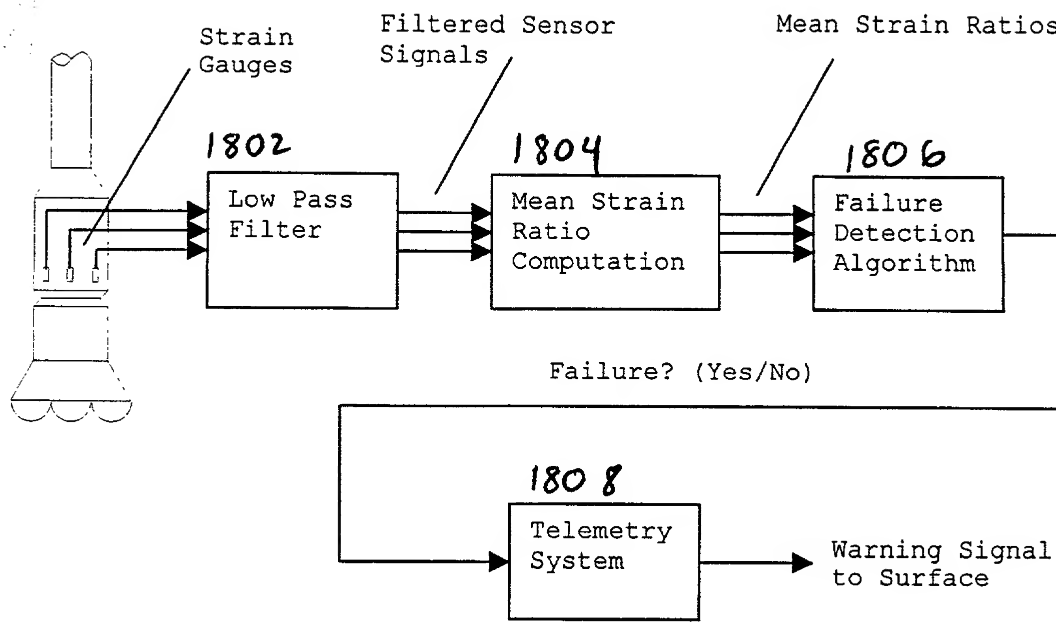


Figure 18. Schematic of MSRA Failure Detection Scheme

Strain Gauge for No Bearing Damage

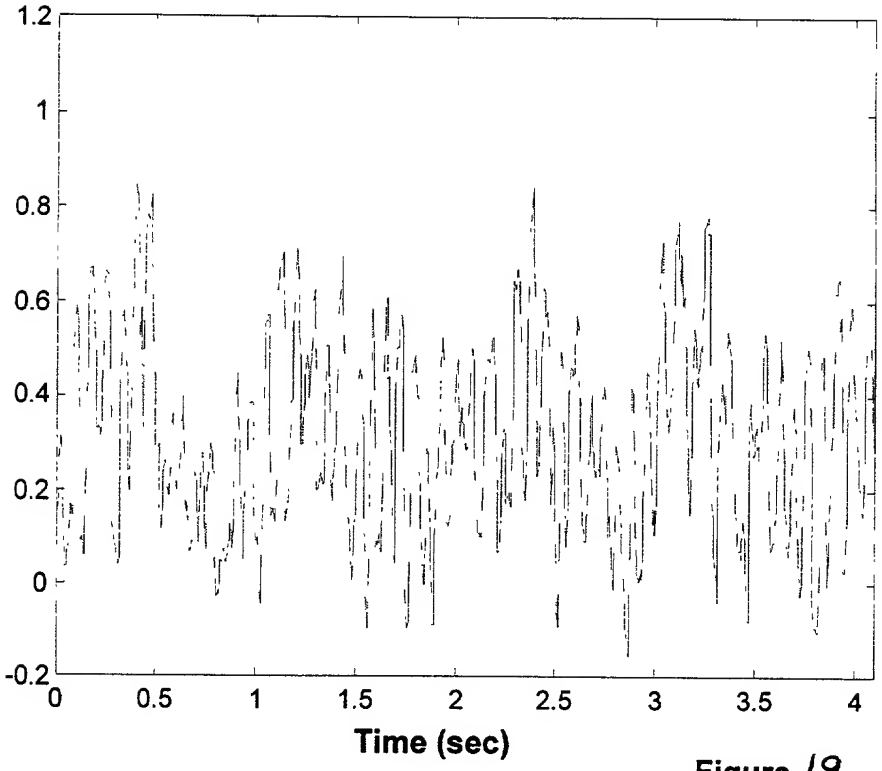


Figure 19

Discrete FFT of Strain Gauge Signal for No Bearing Damage

Discrete FFT of Strain Gauge Signal for No Bearing Damage

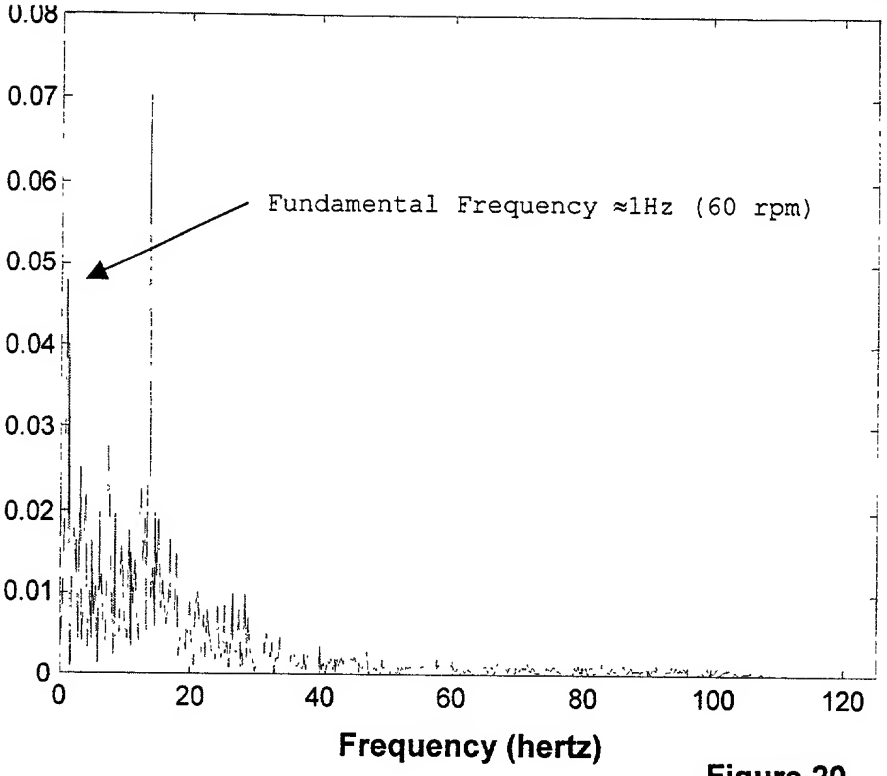


Figure 20.

Mean Strain Analysis for Bearing with No Damage

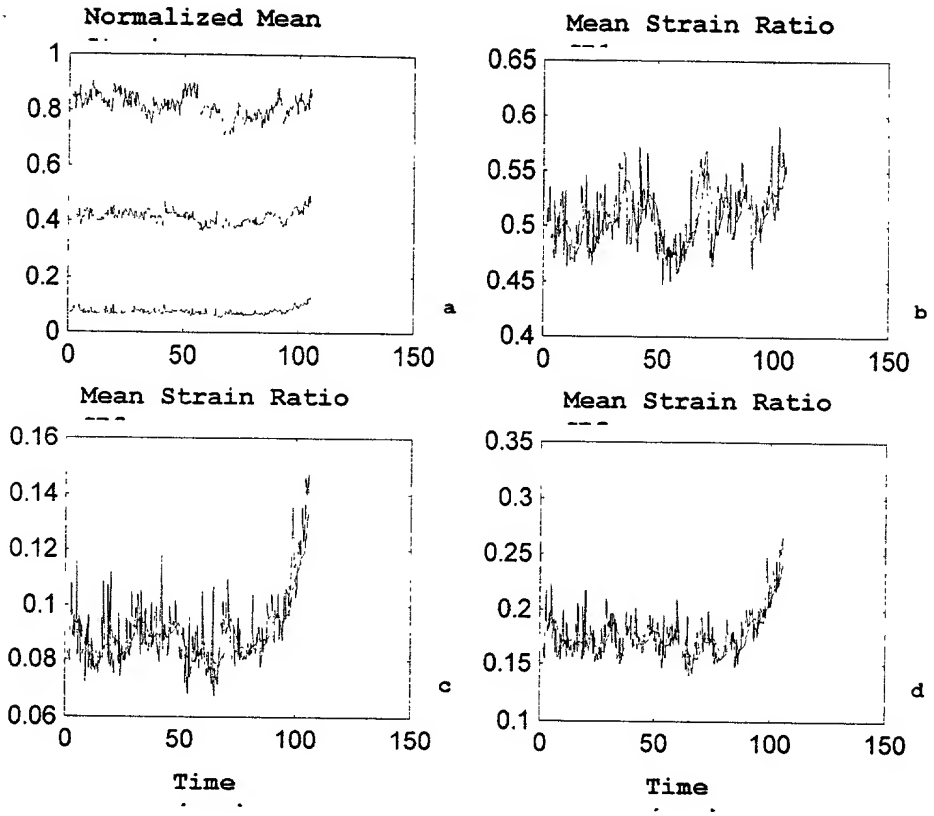


Figure 21.

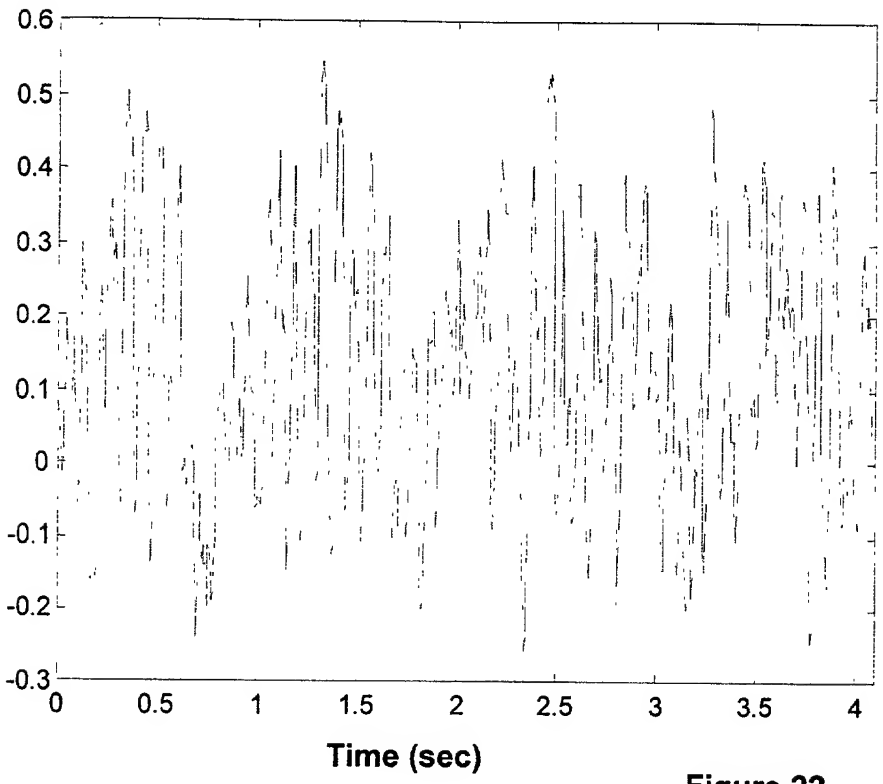


Figure 22.

Discrete FFT of Strain Gauge Signal for Light Bearing Damage

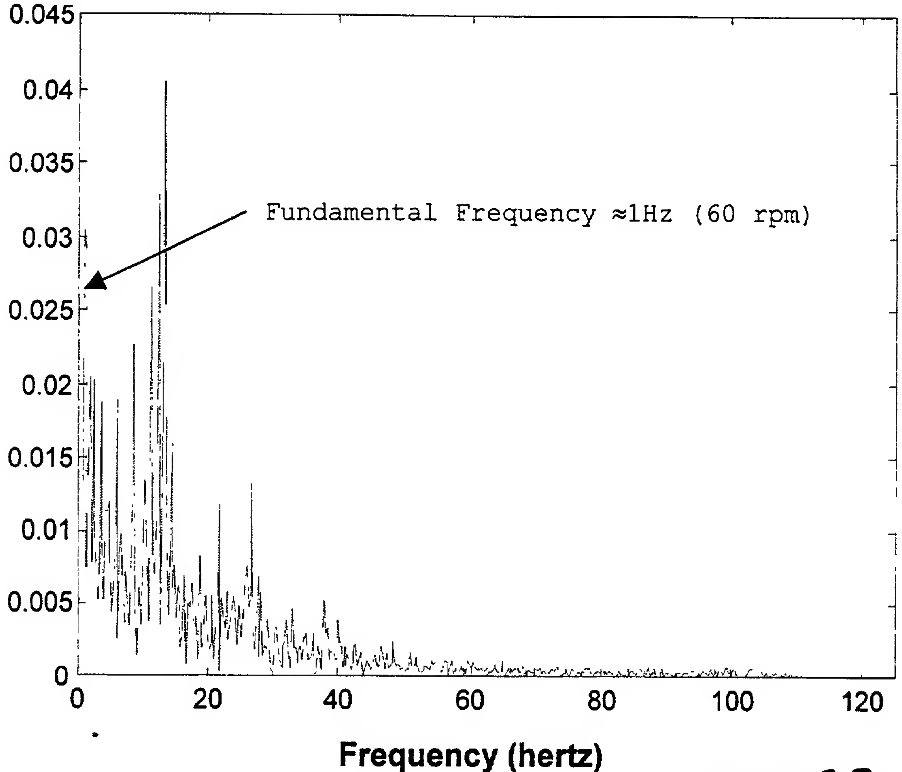


Figure 23

Mean Strain Analysis for Bearing with Light Damage

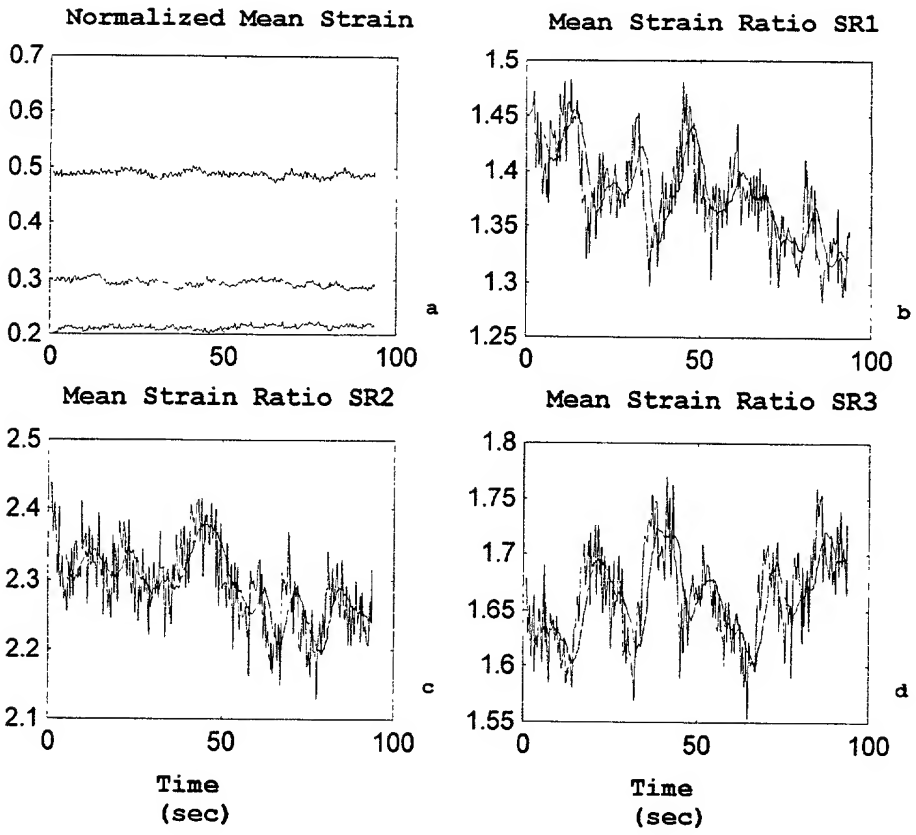


Figure 24

Strain Gauge Signal when Bearing Moderately Damaged

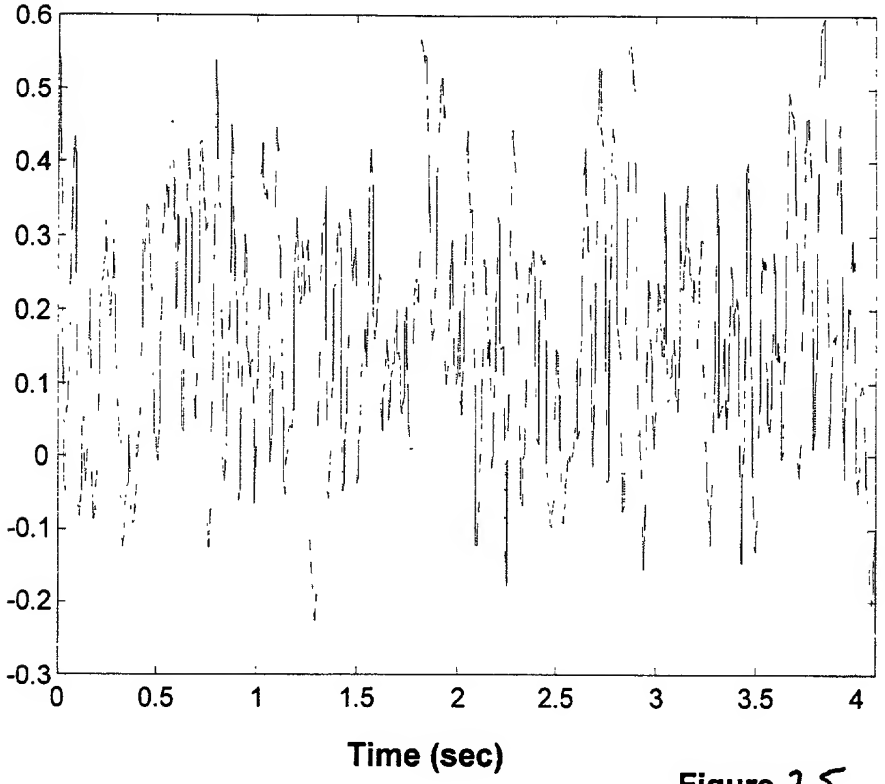


Figure 25

Discrete FFT of Strain Gauge Signal for Moderate Bearing Damage

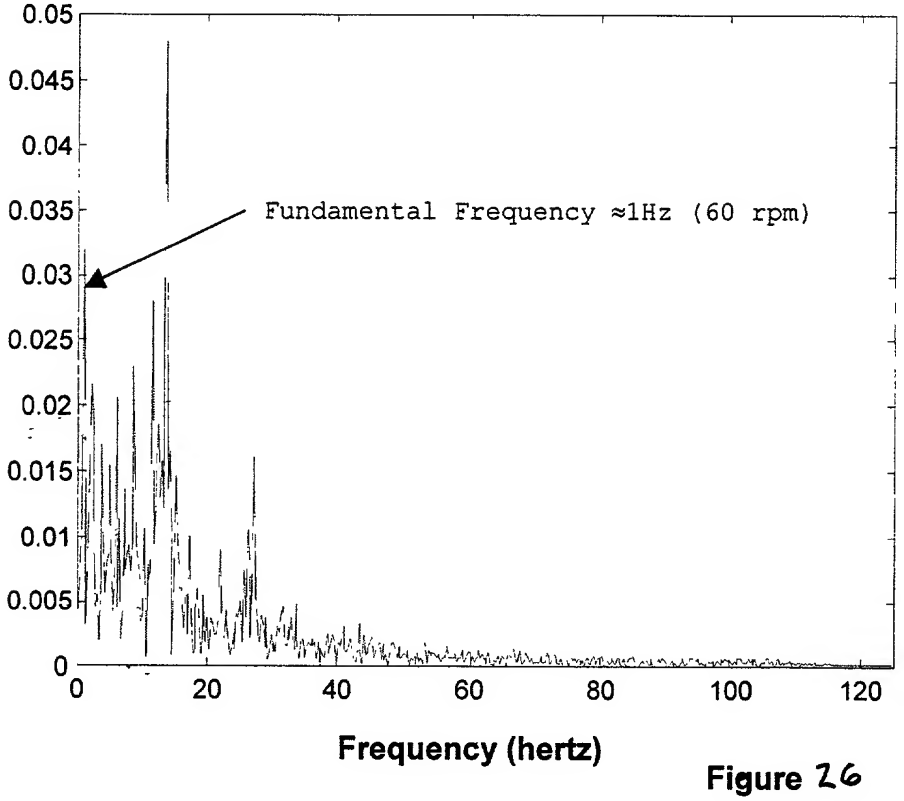


Figure 26

Mean Strain Analysis for Bearing with Moderate Damage

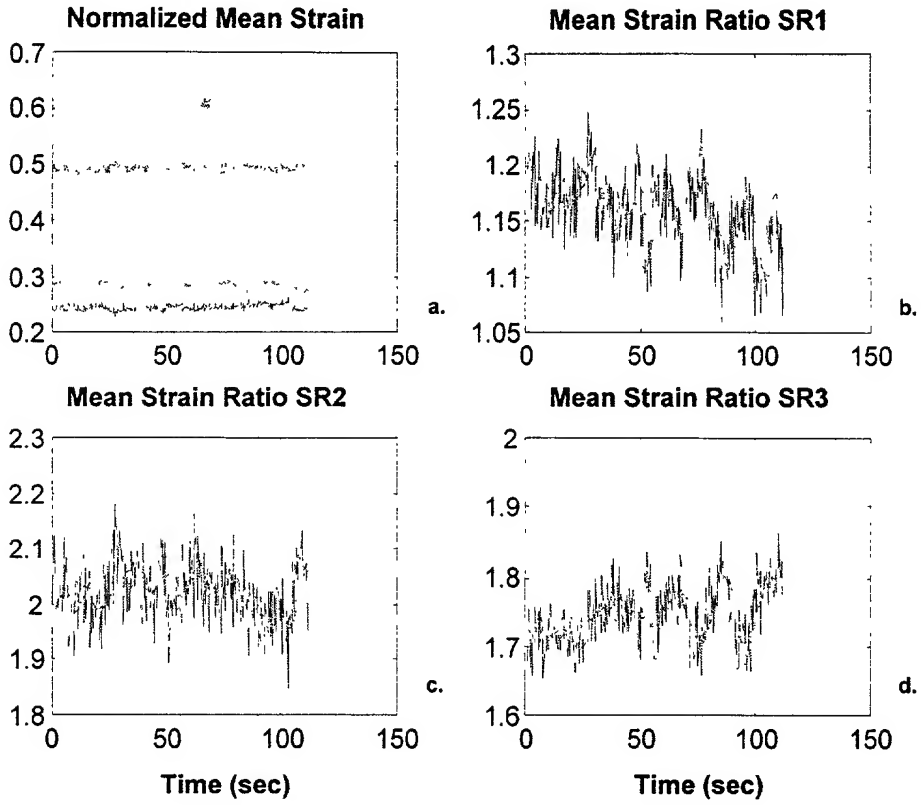


Figure 27

Strain Gauge Signal with Bearing In Early Failure

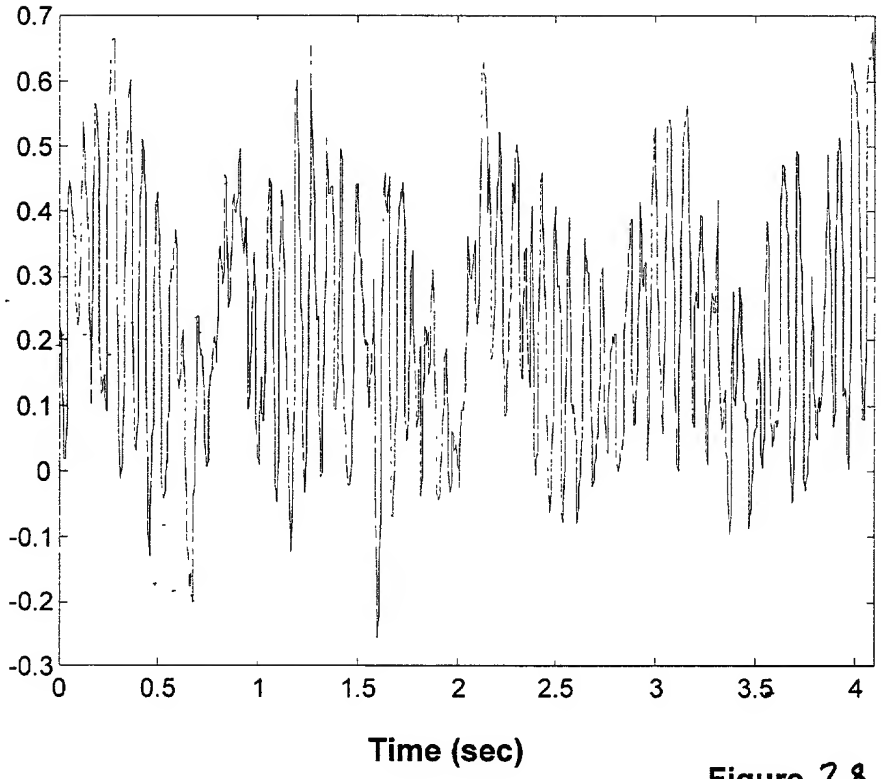


Figure 28

Discrete FFT of Strain Gauge Signal for Bearing In Early Failure

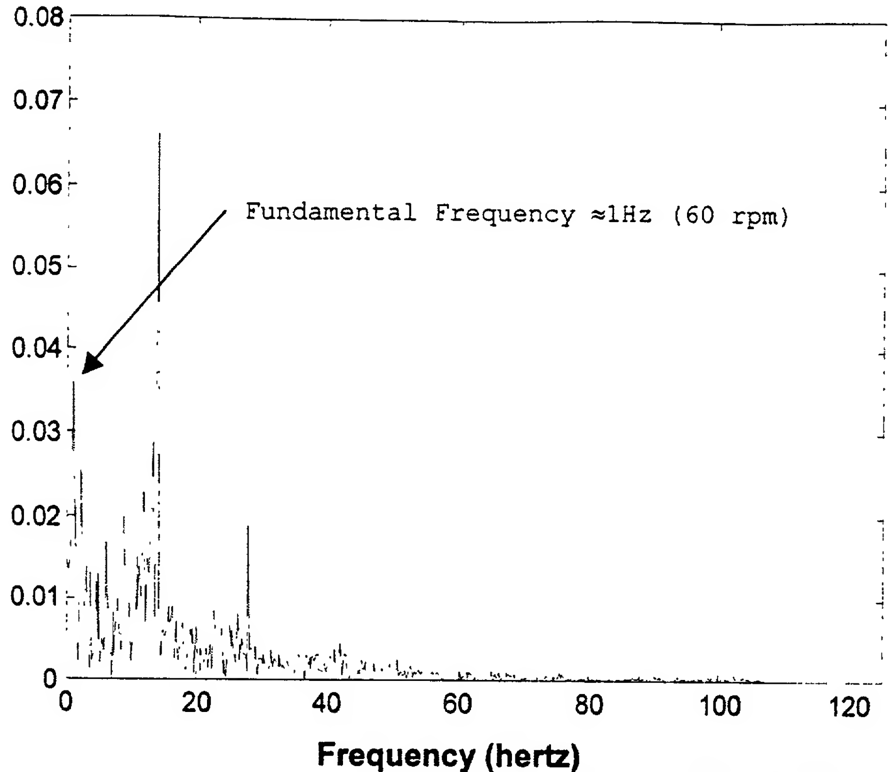


Figure 29

Mean Strain Analysis for Bearing in Early Failure

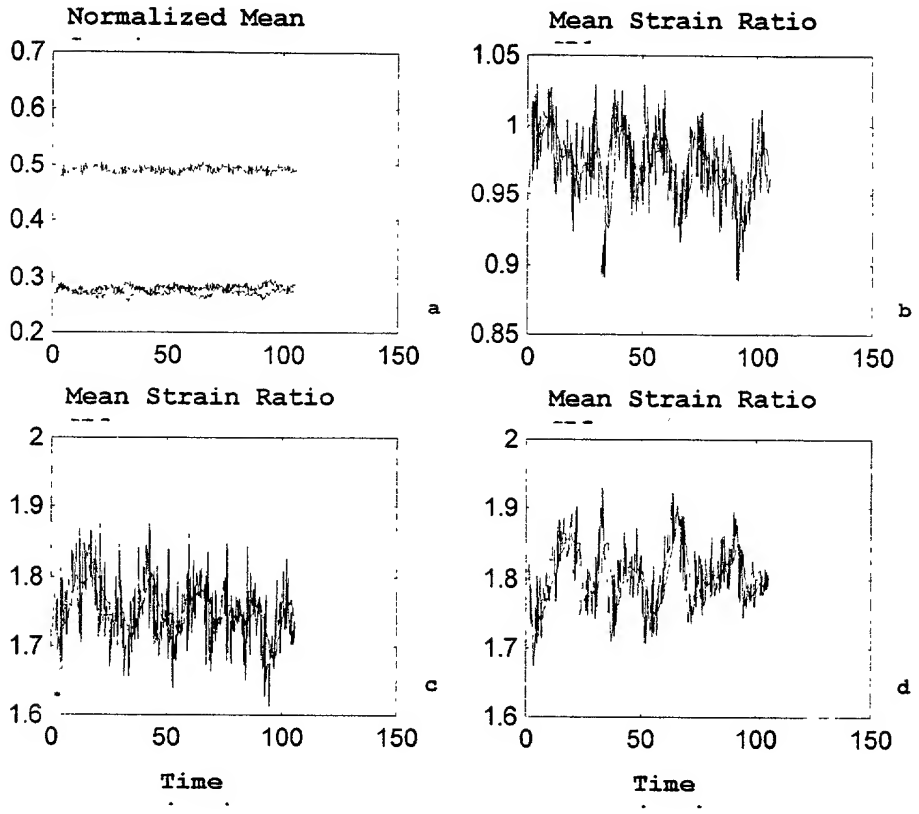


Figure 30.

Mean Strain Analysis for Shifting Load Condition

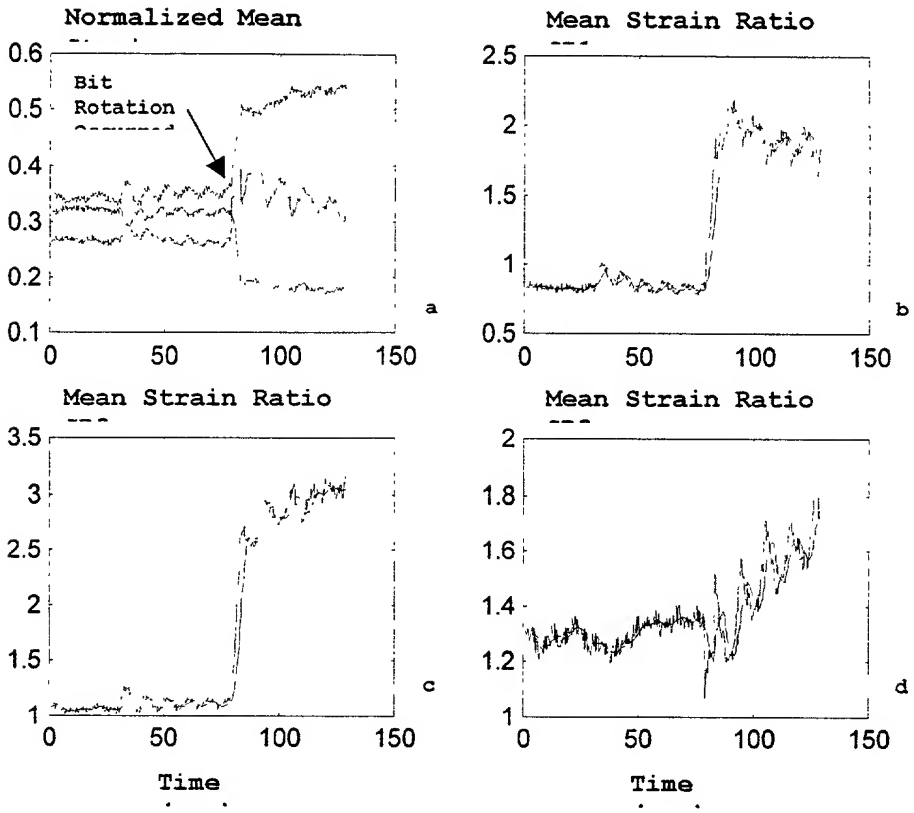


Figure 31.

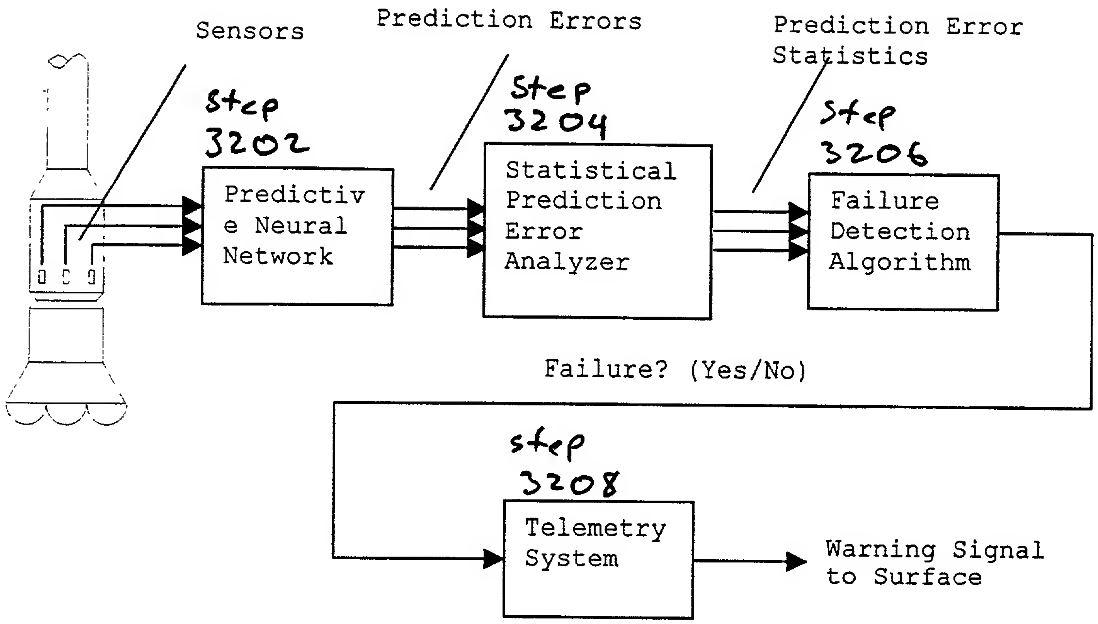


Figure 32 Schematic of ANNPA Bearing Failure Detection Scheme

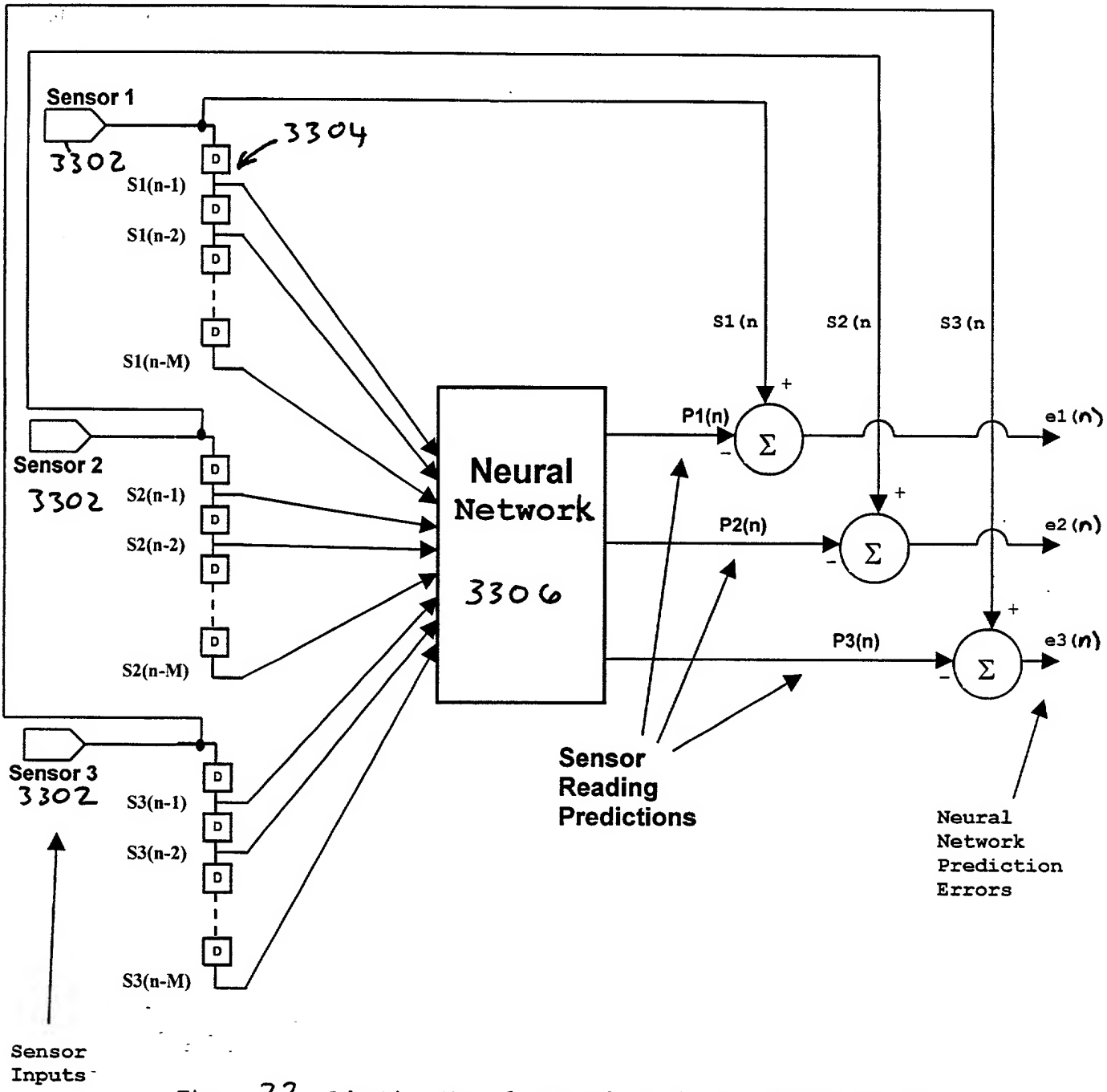


Figure 33 Adaptive Neural Network Predictor (ANNPA Method)

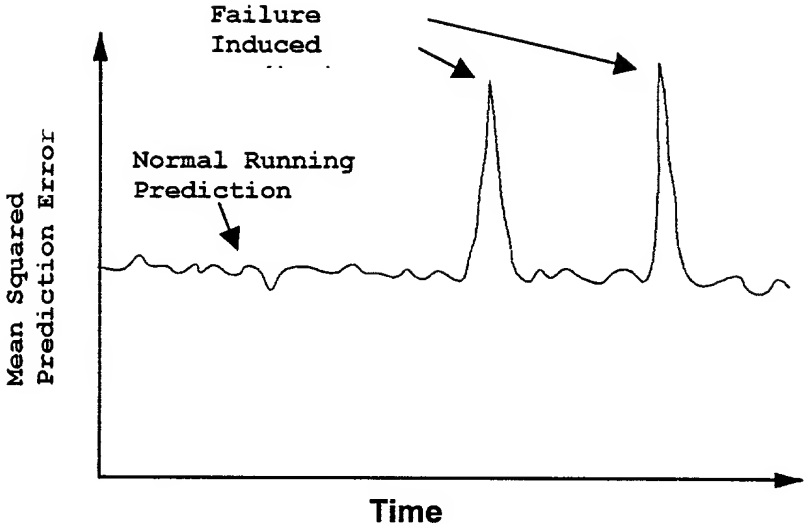


Figure 34 Failure Indications (ANNPA Method)

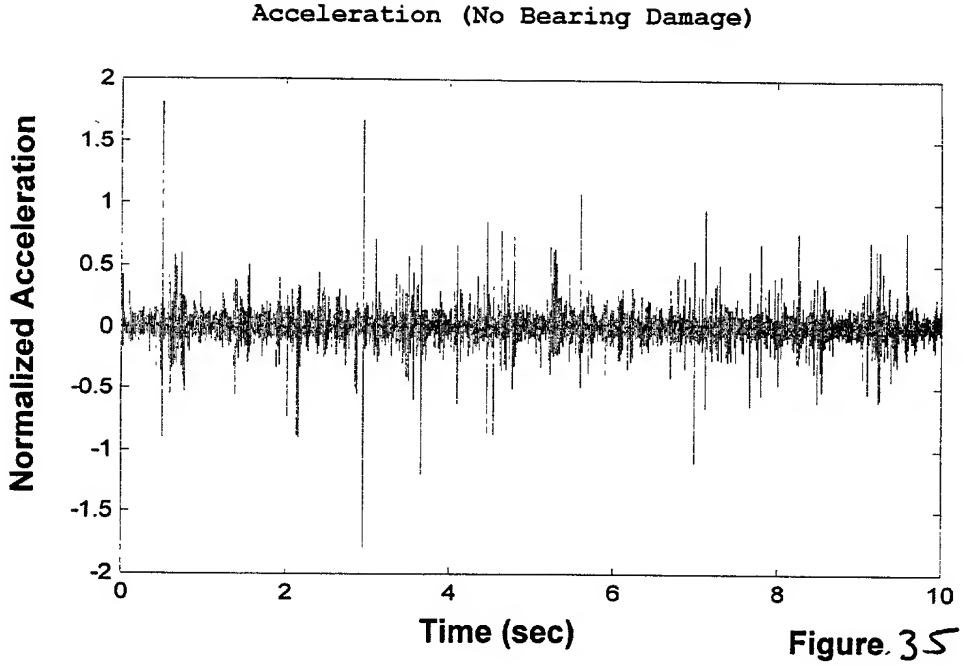


Figure 35

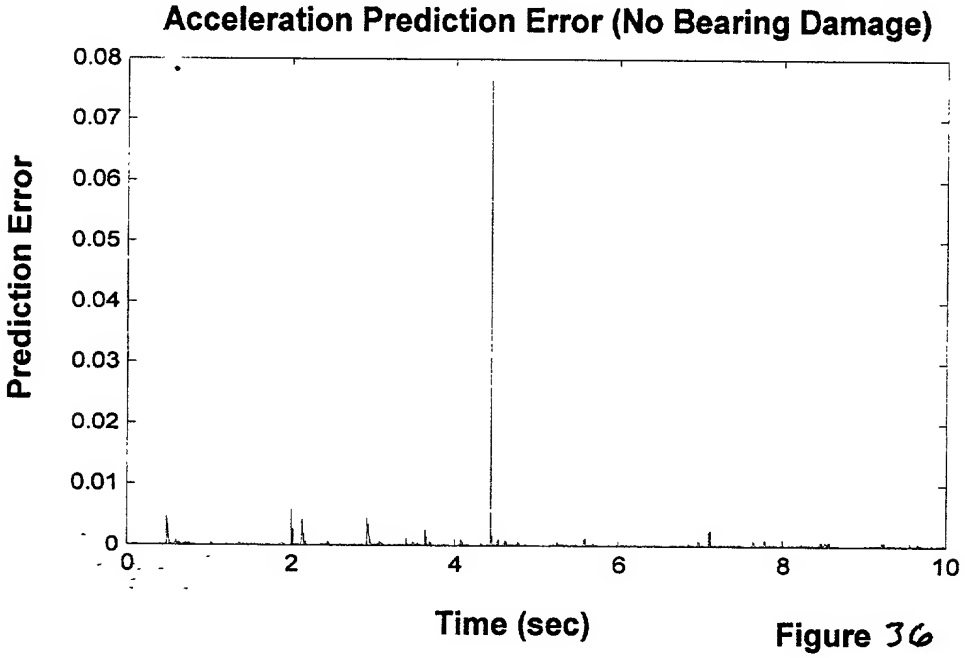


Figure 36

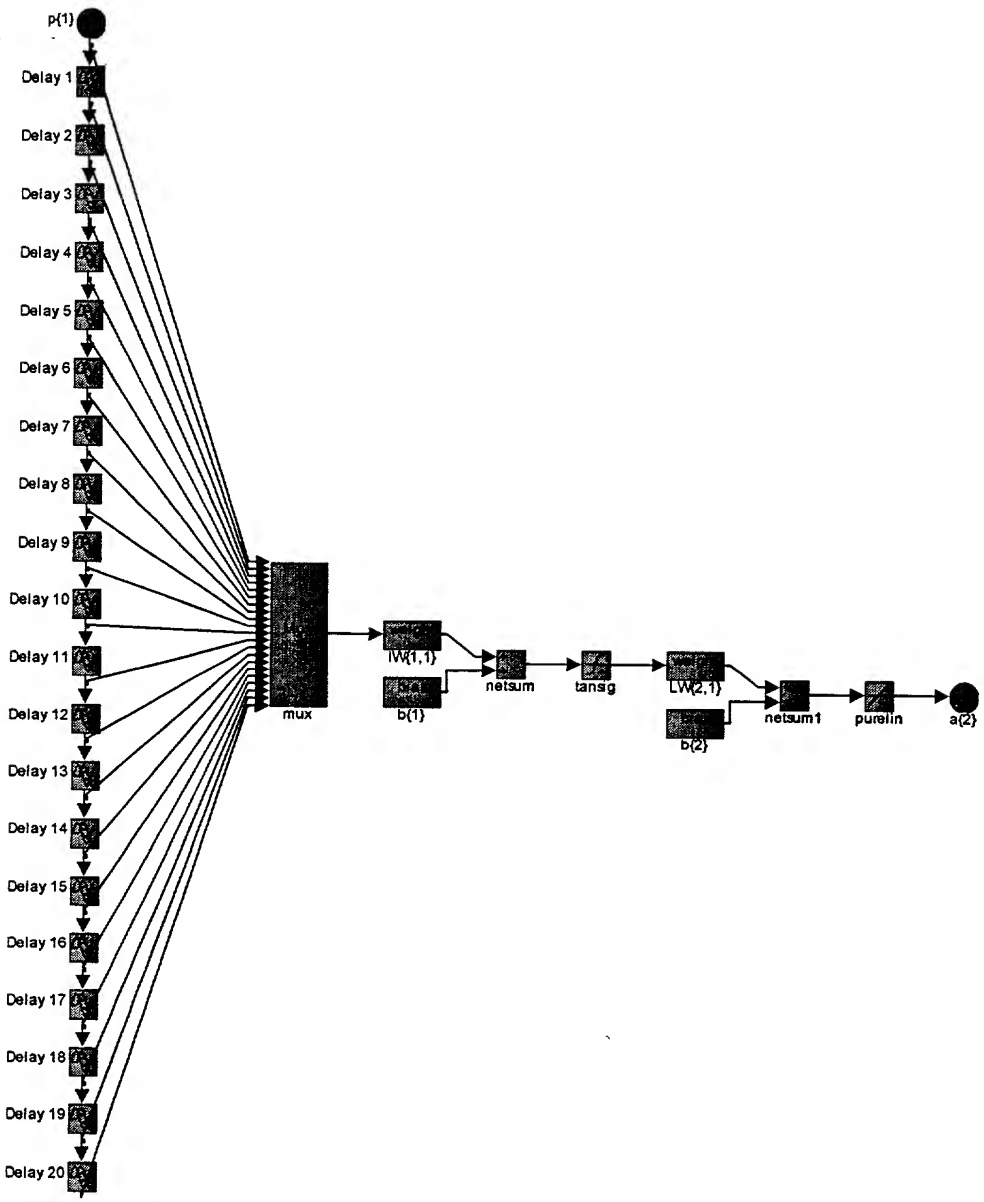

p{1}
Delay 1
Delay 2
Delay 3
Delay 4
Delay 5
Delay 6
Delay 7
Delay 8
Delay 9
Delay 10
Delay 11
Delay 12
Delay 13
Delay 14
Delay 15
Delay 16
Delay 17
Delay 18
Delay 19
Delay 20
mux
IW{1,1}
b{1}
netsum
tansig
LW{2,1}
b{2}
netsum1
purelin
a{2}

Figure 37

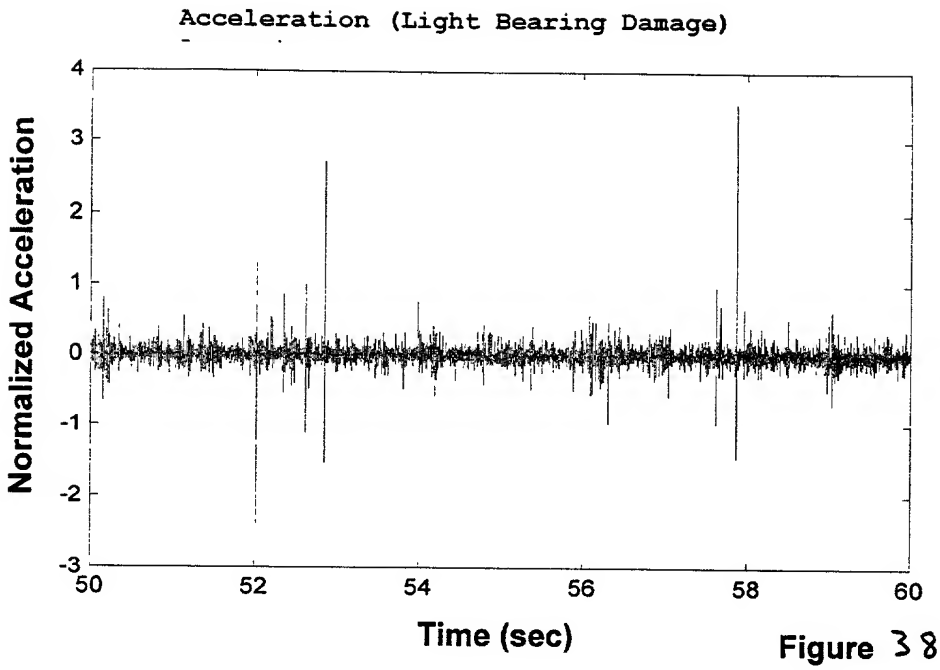


Figure 38

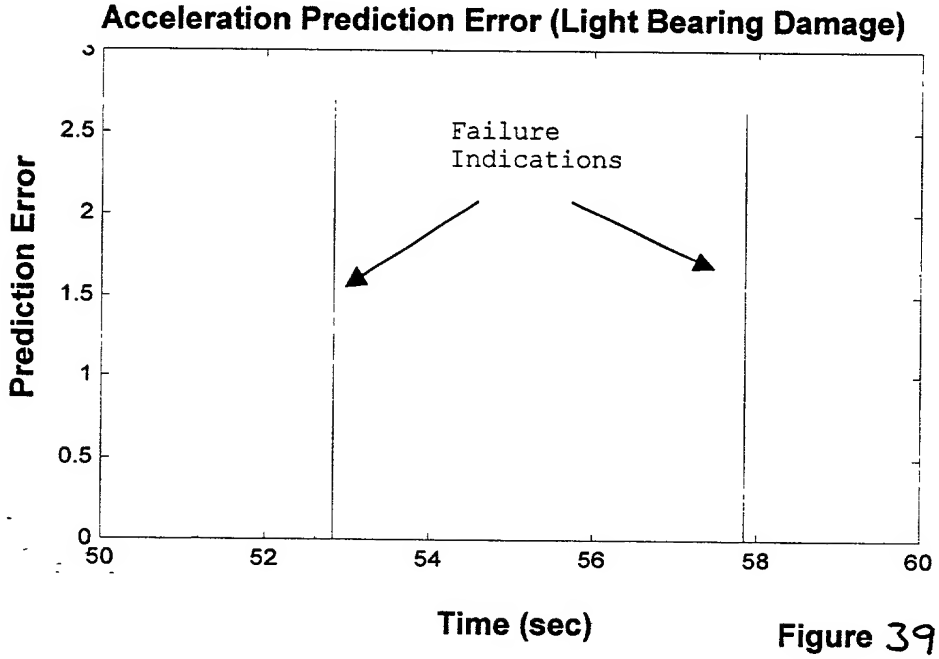


Figure 39

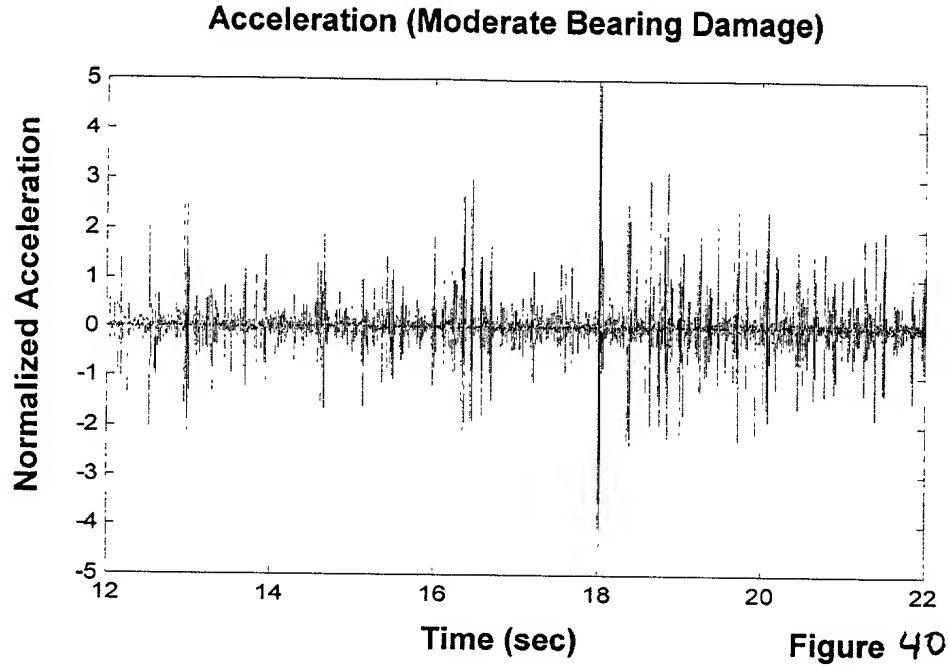


Figure 40

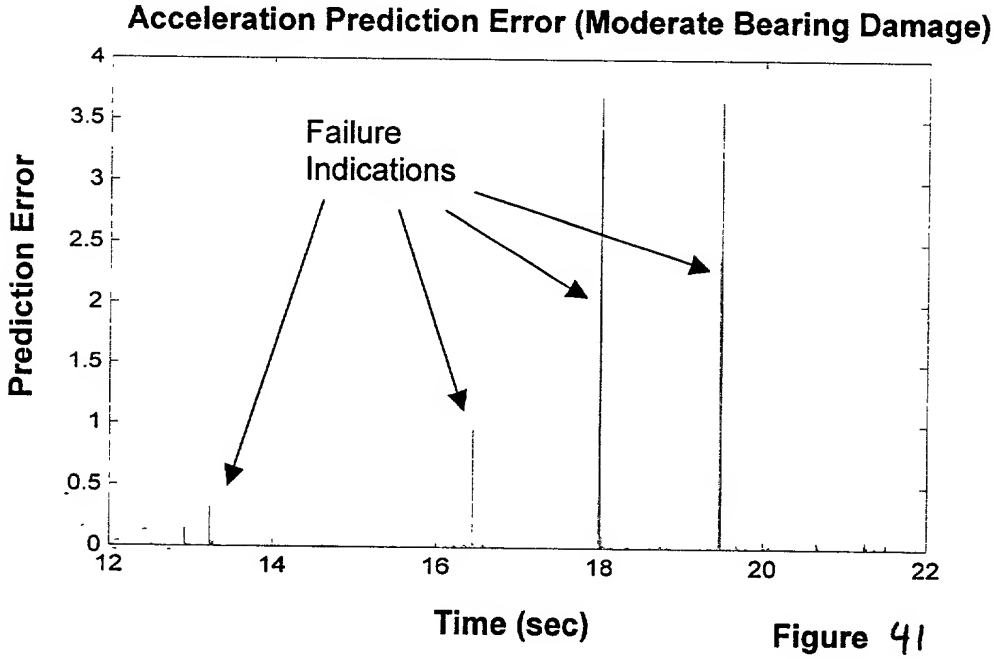


Figure 41

Acceleration (Heavy Bearing Damage)

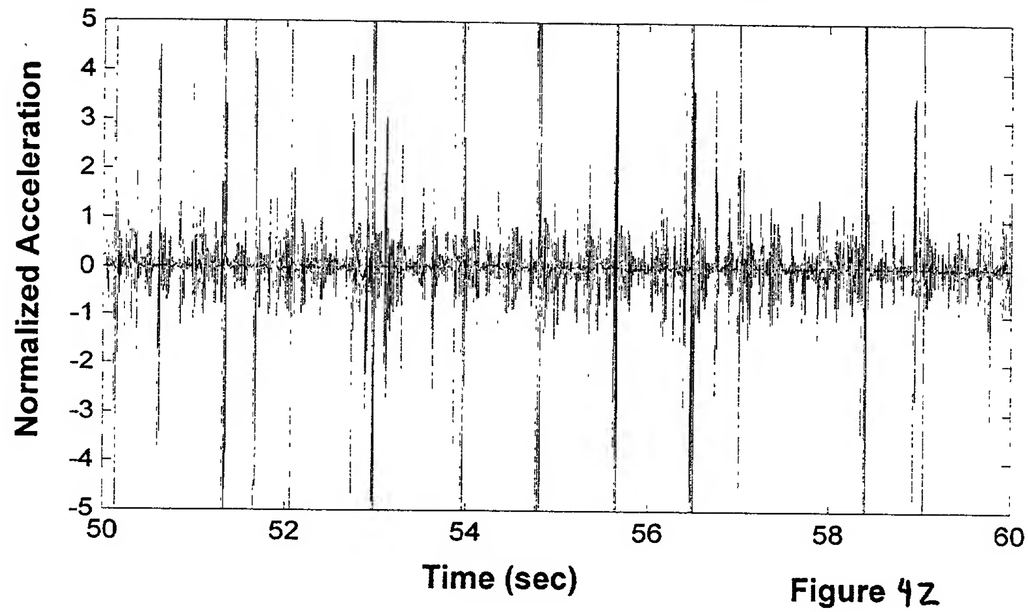


Figure 42

Acceleration Prediction Error (Heavy Bearing Damage)

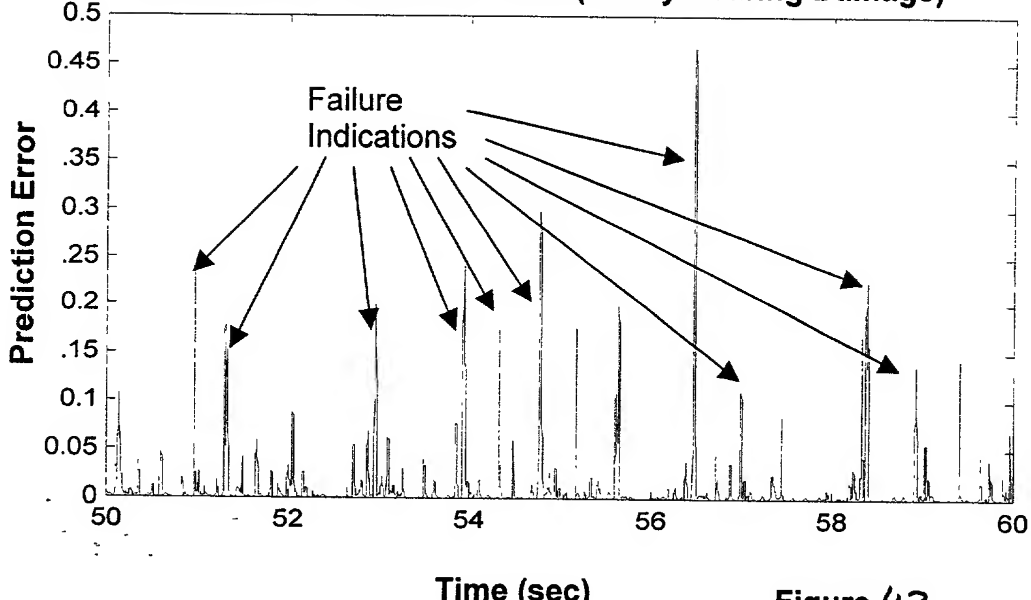


Figure 43

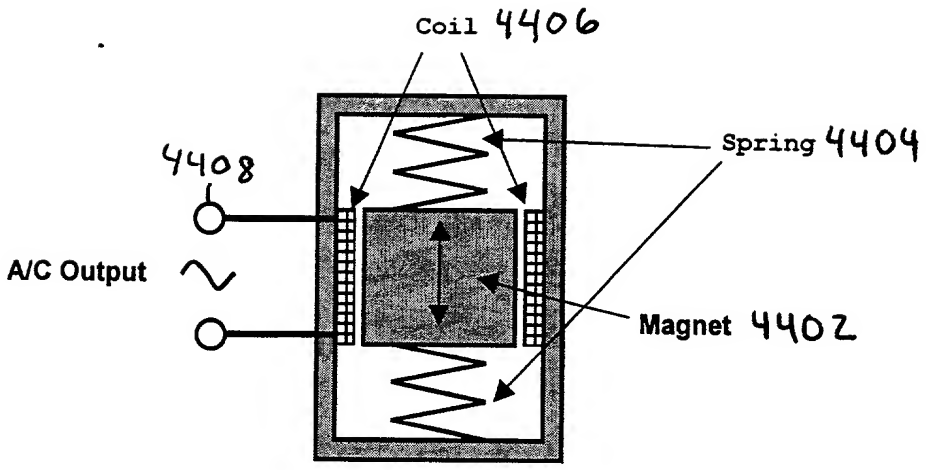


Figure 44 Diagram of Voice Coil Power Generator

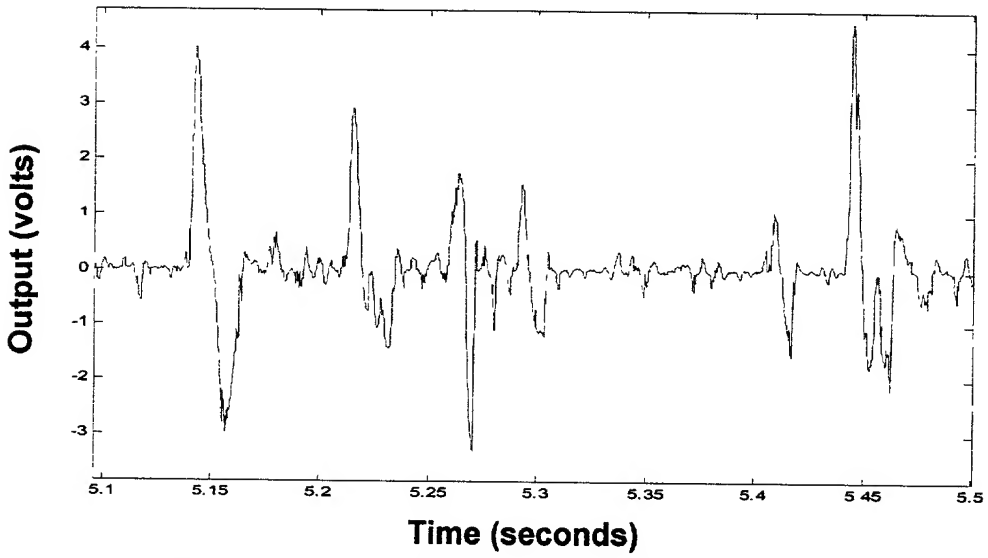


Figure 45 Scaled-Down Prototype Power Generator Output (1000 Ω Load)

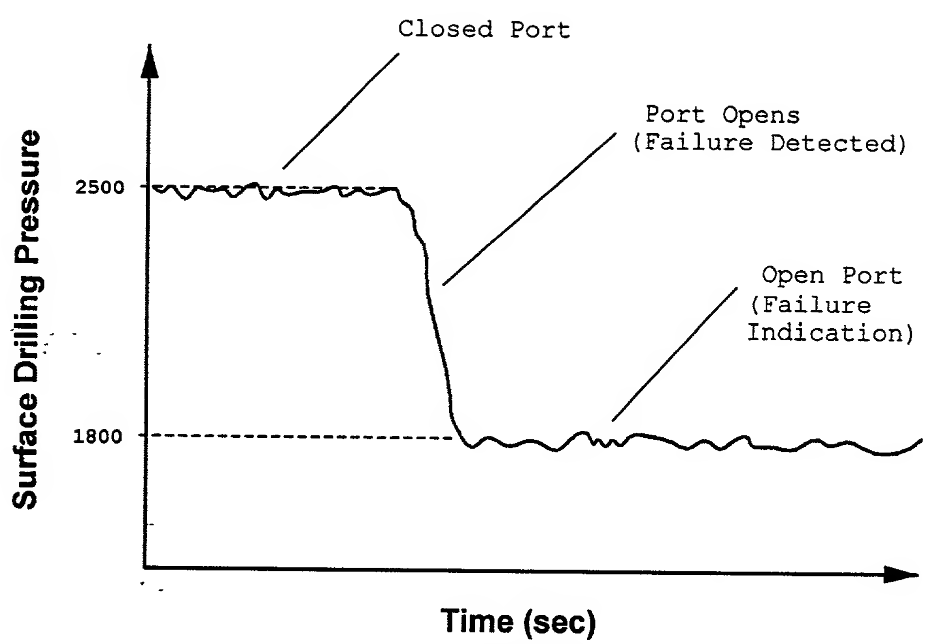


Figure 46 Open Port Failure Indication

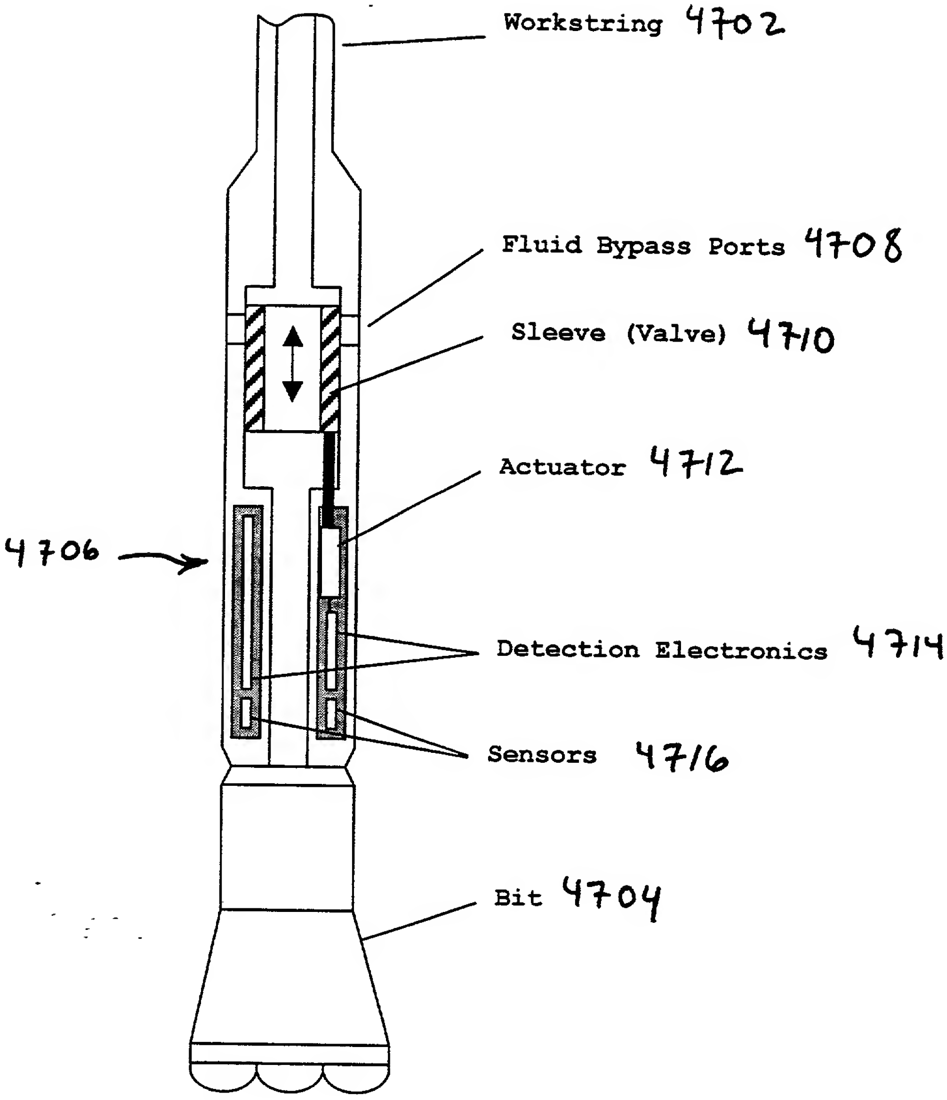


Figure 47 Downhole Tool Schematic

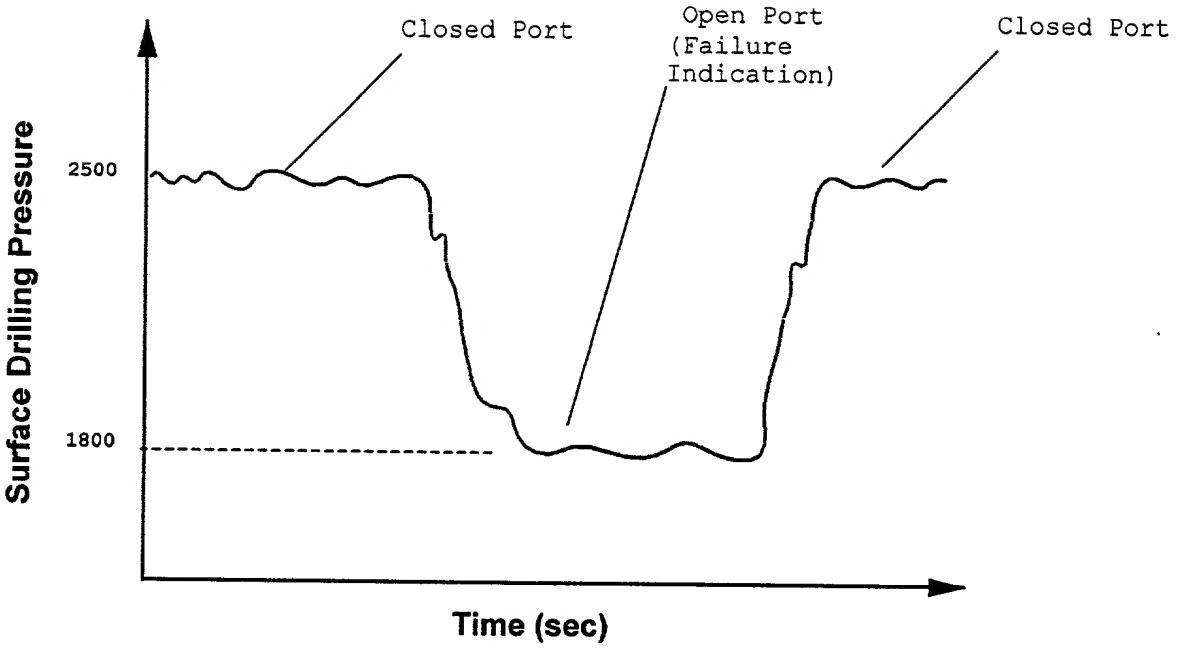


Figure 48 Open-Close Signaling Operation

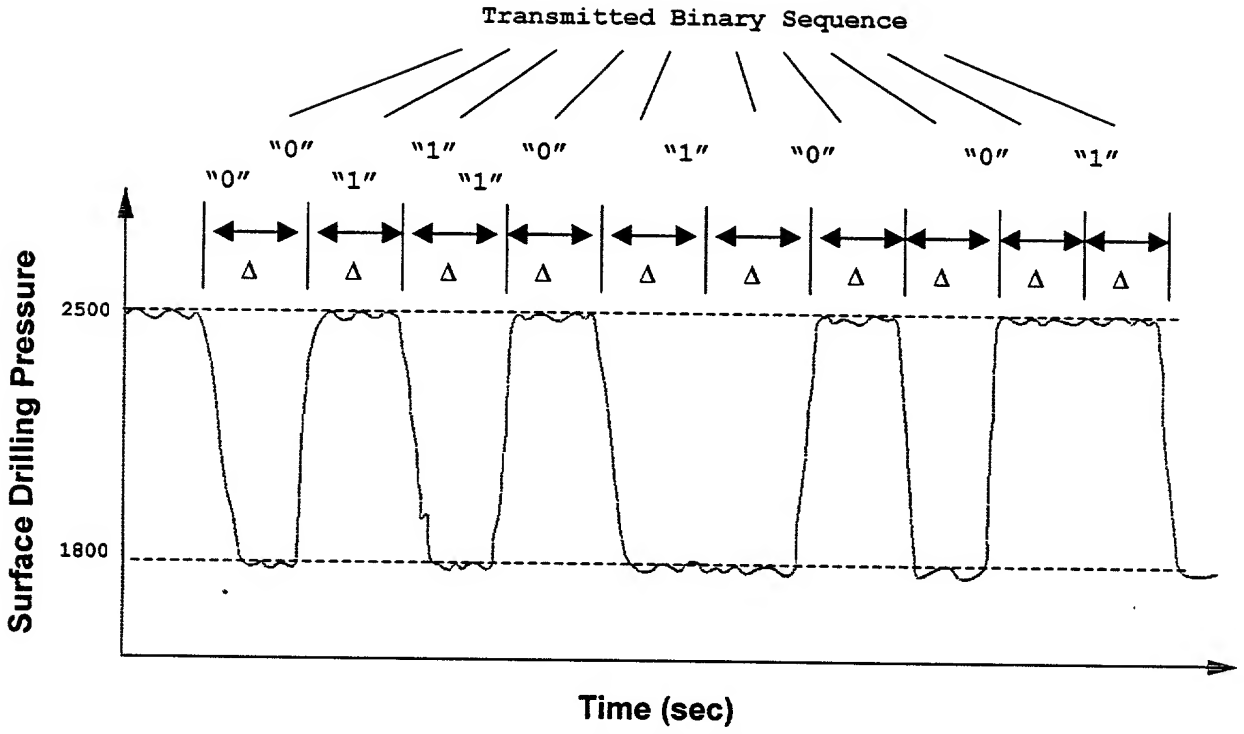


Figure 49 Binary Data Transmission Using Static Pump Pressure Levels

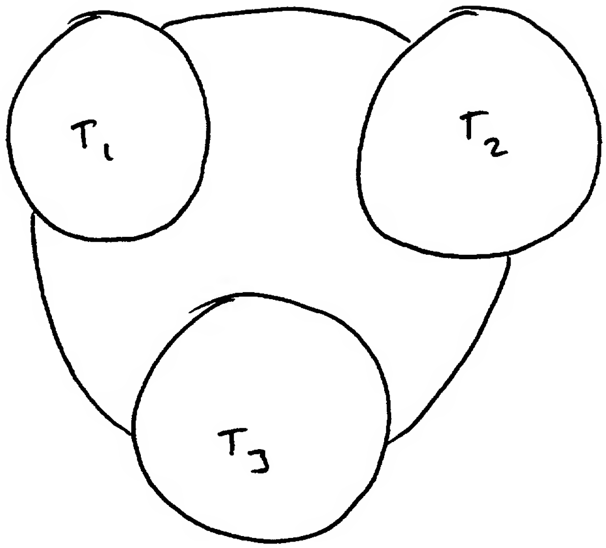


Figure 50

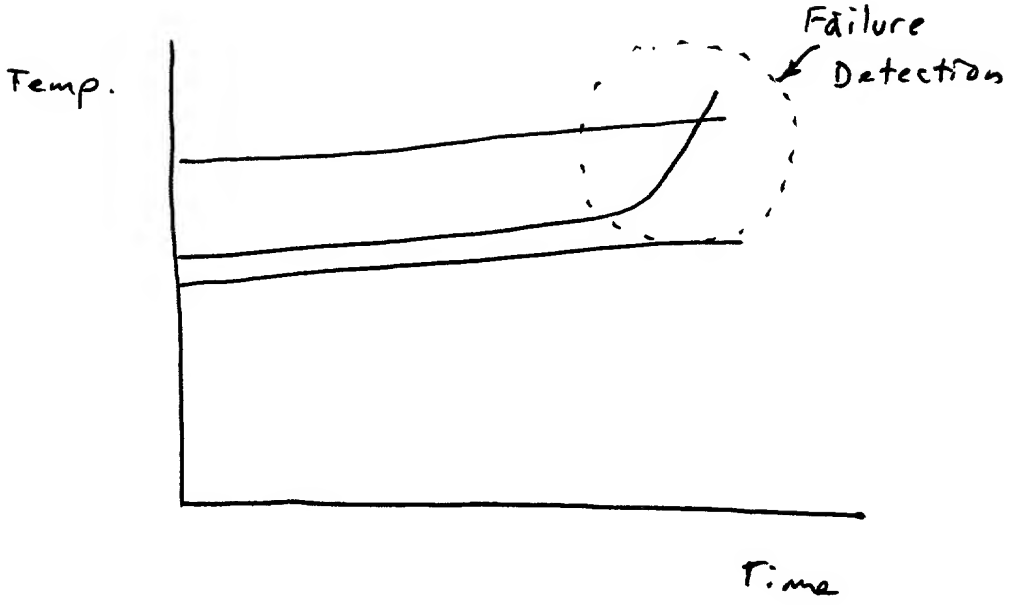


Figure 51

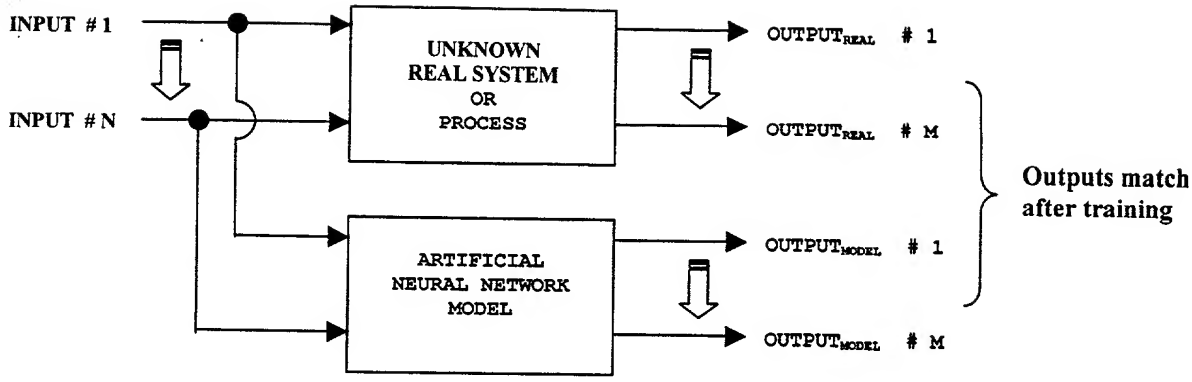


Figure 52 Neural Network Modeling
Real System

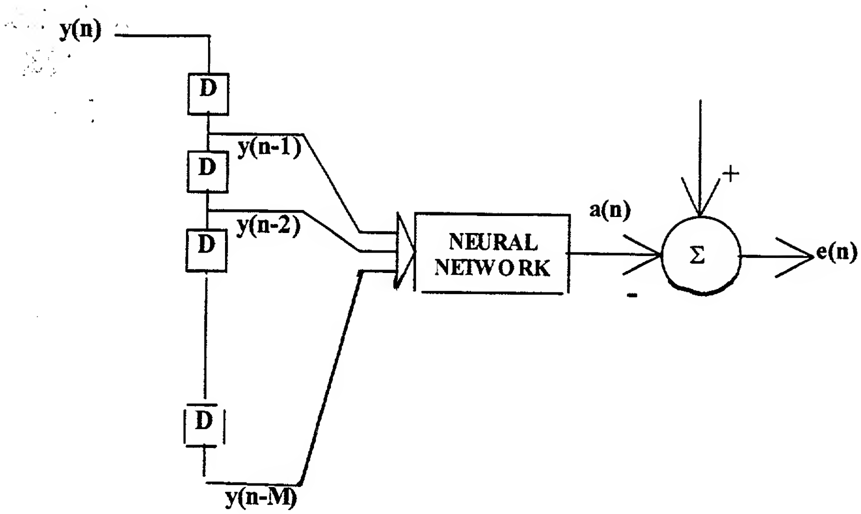


Figure 53

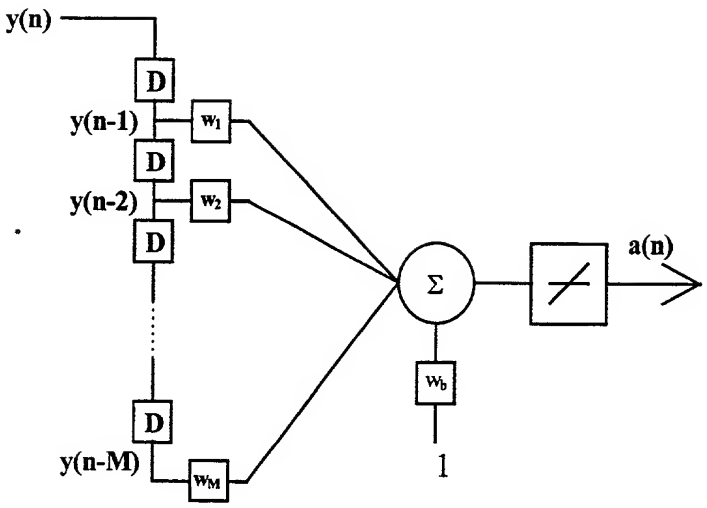


Figure 54 Basic Linear Network

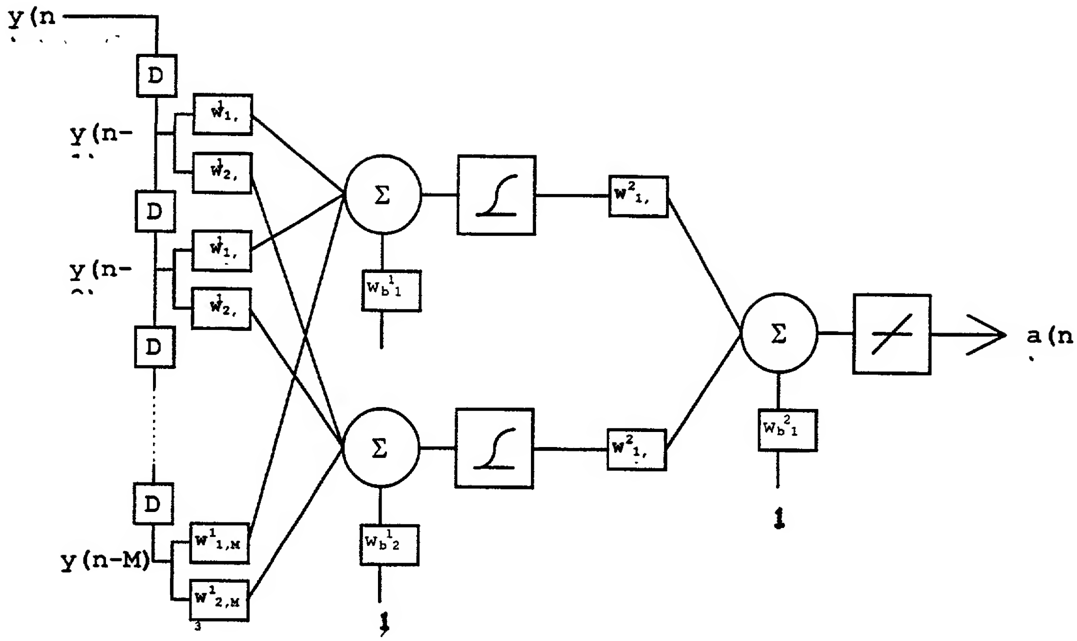


Figure 55

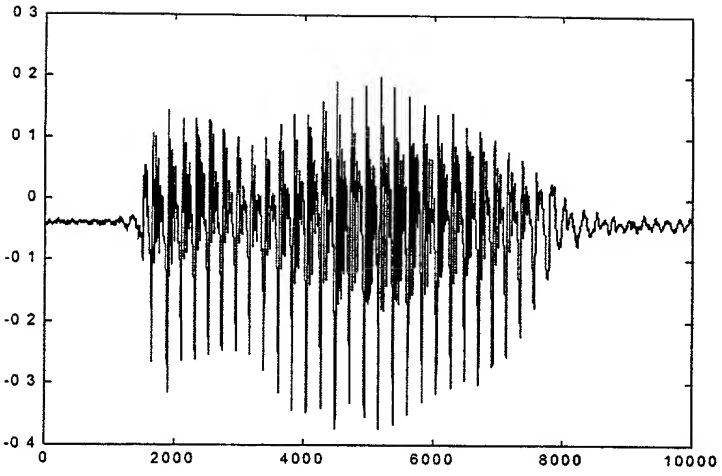
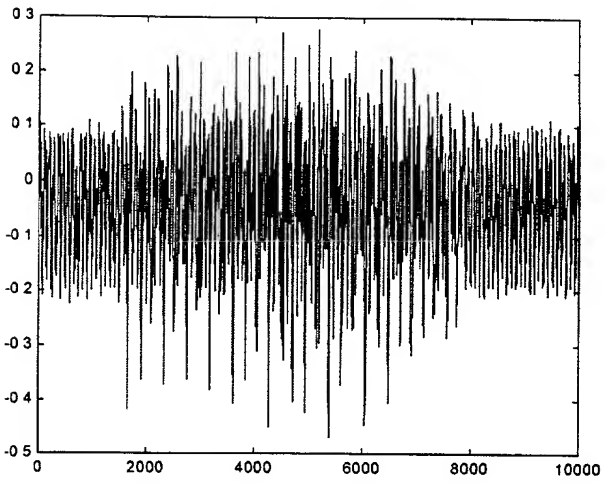
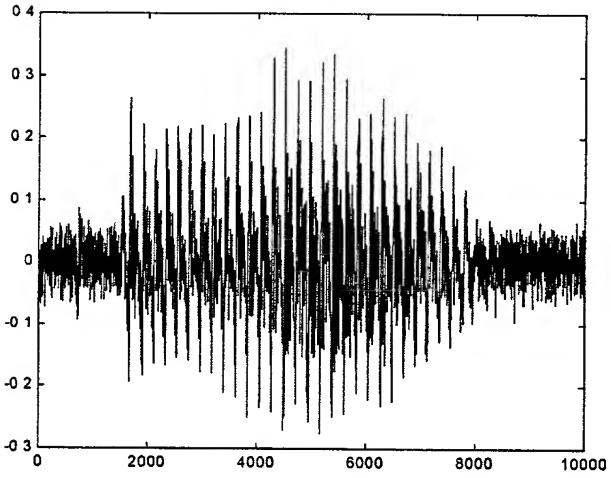


Figure 56

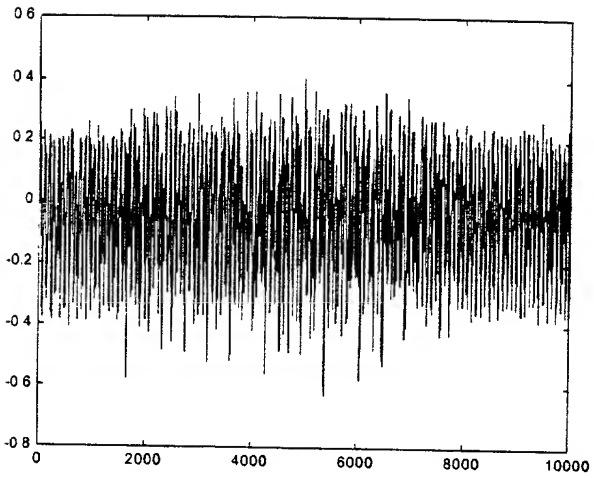


Corrupt Signal S/N Ratio = .95

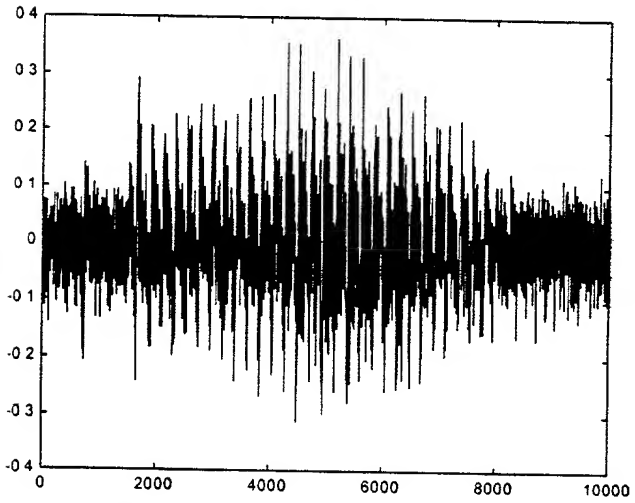


Filtered Signal S/N Ratio = 2.35

Figure 57

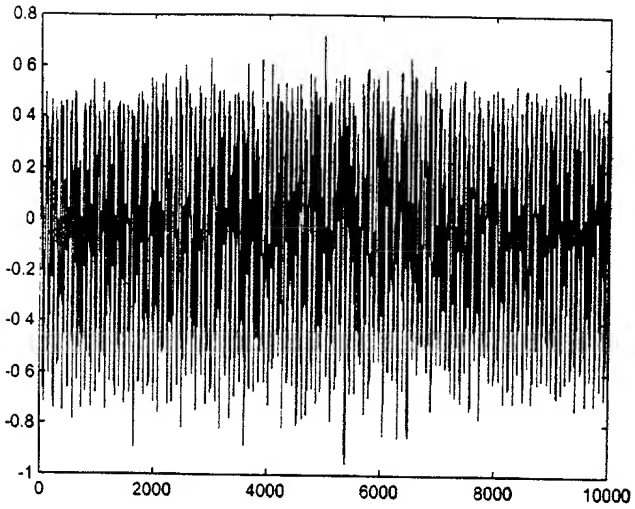


Corrupt Signal S/N Ratio = .24

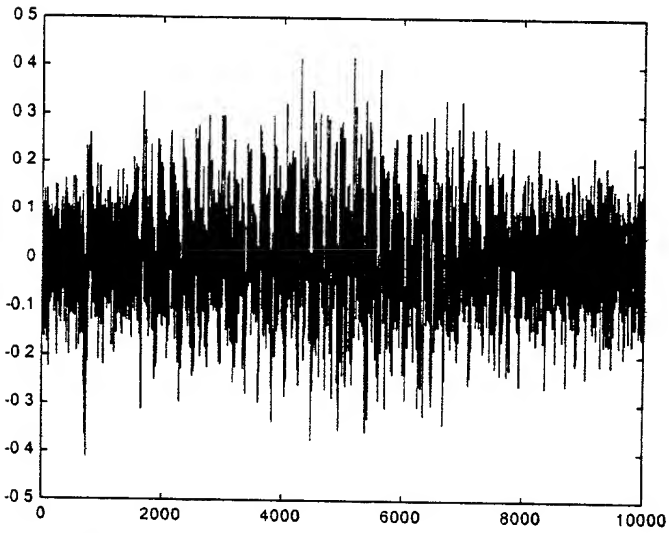


Filtered Signal S/N Ratio = 1.68

Figure 58

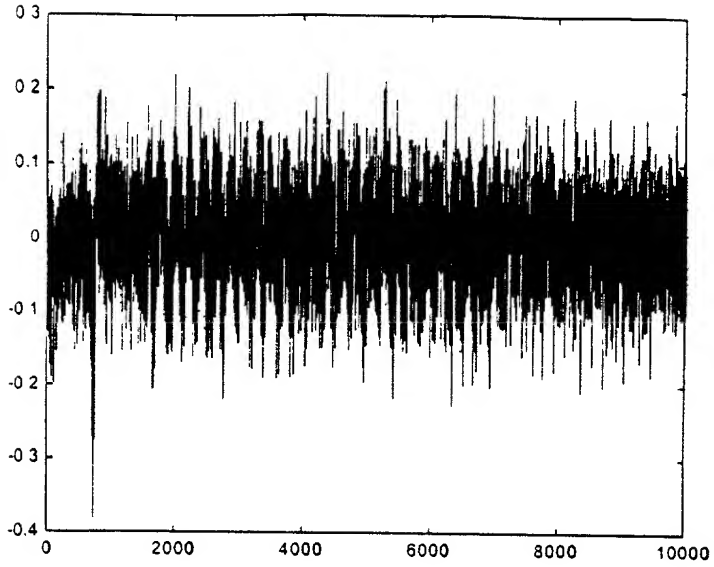


Corrupt Signal S/N Ratio = .06



Filtered Signal S/N Ratio = .89

Figure 59



Linear filter results. S/N = .7457

Figure 60